ISSN 0377-9335

entomon

A Quarterly Journal of Entomological Research

Vol. 7 DECEMBER 1982 No. 4

PUBLISHED BY
THE ASSOCIATION FOR ADVANCEMENT OF ENTOMOLOGY
DEPARTMENT OF ZOOLOGY, UNIVERSITY OF KERALA, KARIAVATTOM
TRIVANDRUM, INDIA 695 581

ENTOMON

Entomon is a quarterly journal of the Association for Advancement of Entomology issued in March, June, September and December, devoted to publication of research work on various aspects of insects and other land arthropods.

Address MS and all editorial correspondence to the Managing Editor, *Entomon*, Department of Zoology, University of Kerala, Kariavattom, Trivandrum, India, 695 581.

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FEEDING POTENTIAL AND DEVELOPMENT OF *CHRYSOPA SCELESTES* BANKS ON *HELIOTHIS ARMIGERA* (HUBN.) UNDER LABORATORY CONDITIONS

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(Received 12 June 1982)

A study was conducted to find out the ability of *Chrysopa scelestes* Banks to consume eggs and larvae of *Heliothis armigera* (Hubn.) in the laboratory. Eggs and larvae (1-3 day old) of the prey were given to *C. scelestes* larvae which were confined individually in 7×2.5 cm glass vials. During development, one individual predator larva consumed 665.4 eggs or 410 larvae of *H. armigera*. The average daily consumption of eggs and larvae by *C. scelestes* was 77.3 and 35.2 respectively. Second and third instars are very voracious and hence they could be used for field studies. The predator completed larval development in 8.60 days on host eggs and 11.70 days on host larva. Difference in the pupal period of of *C. scelestes* reared on eggs and larvae were not significant.

(Key words: Chrysopa scelestes, Heliothis armigera, feeding petential)

INTRODUCTION

Heliothis armigera (Hubn.) is a widely distributed and highly polyphagous pest in the old world, attacking over 50 species of cultivated plants of which pulses, cotton and tomato are the most seriously damaged in addition to lucerne, tobacco, maize, sorghum etc. In india, five reduviid predators have been reported on *H. armigera* (RAO, 1974). Later MANJUNATH *et al.*, (1976) reported *Chrysopa carnea* Steph. attacking *H. peltigera* (Schiff) However, their impact on *Heliothis* populations in the field is not known, nor have any attempts been made to mass multiply them for inundative releases.

As inundative releases of *Chrysopa* spp. have been found to bring immediate and direct reduction in target pest populations (LINGREN *et al.*, 1968, RIDGWAY & JONES, 1968, 1969), *C. scelestes* Banks, one of the native predators, found feeding on eggs and neonate larvae of *H. armigera* in the laboratory was considered for inundative release programmes. Before making field releases, to have additional information on the ability of *C. scelestes* to consume *H. armigera* eggs and larvae, the present study was conducted.

MATERIALS AND METHODS

The culture of *C. scelestes* was reared on eggs of *Corcyra cephalonica* (Staint.) as described by KRISHNAMOORTHY & NAGARKATTI (1982). A laboratory colony of *H. armigera* was maintained on the artificial diet described by NAGARKATTI & SATYA PRAKASH (1974) Adult moths were allowed to lay eggs on muslin cloth. Eggs were removed from the cloth by treating with 10% sodium hypochlorite solution for 30 to 60 sec and then rinsed with water. These eggs were used for feeding the larvae of *C. scelestes*. The predator larvae after hatching were confined in labelled 7×2.5 cm glass vials individually and provided with a known number of fresh *H. armigera* eggs. The vials were plugged with

Contribution No. 76/82 of the Indian Institute of Horticultural Research, Bangalore-80.

cotton. Observations were made every 24 hr on the number of eggs eaten. Eggs which had been attacked but only partially eaten were also considered as eaten. Surviving eggs were removed and fresh eggs were offered to the predator daily. This was repeated with 10 predators considering each individual as one replicate.

Similarly, another batch of the *C. scelestes* larvae was provided with 1—3 day old *H. armigera* larvae reared on artificial diet. Both the predator and prey larvae were confined in glass vials (7×2.5 cm) and artificial diet was provided for the *H. armigera* larvae to feed on. After 24 hr the surviving *Heliothis* larvae were removed from the vials and fresh larvae were offered to the predator.

Eggs and larvae of *H. armigera*, were provided daily to the predator larvae until cocoon formation. The cocoons were separated for adult emergence. Observations were recorded on consumption of *H. armigera* eggs and larvae, developmental time of different larval instars and pupal period of *C. scelestes* when reared on each diet.

All rearing and testing were done at 26±1°C and 60—80% RH.

RESULTS AND DISCUSSION

The number of *H. armigera* eggs consumed during the first, second and third instars of the predator averaged 35.6, 201.4 and 428.4 respectively (Table 1). A total of 665.4 eggs were consumed by the predator during the entire larval developmental period. Whereas the same predator species has consumed a total of 741.0 *C. cephalonica* eggs under similar conditions (KRISHNAMOORTHI, 1982). The lesser number of eggs consumed by the predator in the case of *H. armigera* may have been due to the larger size of *H. armigera* eggs. When *H. armigera* larvae (1-3 day old) were offered, the predator consumed 41.2, 32.3 and 335.2 larvae during the development of first, second and third instar respectively. On an average 410.7 larvae were consumed by the predator which is less than the eggs. On the other hand EL-DAKRODURY *et al.* (1979) have observed that the predator *C. carnea* consumed more of *H. armigera* larvae than eggs. This anomaly may be due to the fact that they used newly hatched larvae as against 1—3 day old larvae used in the present study. The quantum of food available for the predator is more in the case of 1—3 day old *H. armigera* larvae than newly hatched larvae.

The average daily consumption of eggs per predator was 11.8, 94.0 and 126.5 in the first, second and third instars respectively and that of larvae 8.5, 15.6 and 69.9 respectively (Table 1). The second and third instars were more voracious than the first instar and of the former two instars the third instar was

TABLE 1. Consumption of eggs and larvae of *H. armigera* by *C. scelestes*.

State of *Chrysopa* larva	No. of eggs consumed/ predator larva	No. of larvae consumed/ predator larvae	No. of eggs consumed/ predator/ day	No. of larvae consumed/ predator/ day
1st instar	35.0± 3.37	41.2± 8.65	11.8± 3.37	8.5±1.75
2nd instar	201.4±15.40	32.3±10.51	94.0±23.34	15.6±5.61
3rd instar	428.4±19.13	335.2±26.77	126.5±25.26	69.9±5.53
Total consumption	665.4±43.51	410.7±30.85	77.3± 7.45	35.2±2.40

TABLE 2. Duration of development of larval and pupal stages of *C. scelestes* on the eggs and larvae of *H. armigera*.

Stage of *Chrysopa*	Developmental time (days)	
	Egg diet	larval diet
A. Larva		
a) 1st instar	3.00±0.00	4.80±0.26
b) 2nd instar	2.15±0.25	2.10±0.21
c) 3rd instar	3.45±0.37	4.80±0.26
Total	8.60±0.52	11.70±1.15
B. Pupa or Cocoon	8.30±0.48	8.40±0.52

very active. Similar observations were also recorded by LINGREN *et al.* (1968); EL-DAKROURY *et al.* (1979) on *C. carnea;* SAMSON & BLOOD (1980) on *C. signata* Schneider and RU-NGUYEN *et al.* (1975) on *C. lanata* Banks. The efficiency of feeding of *Chrysopa* increased greatly with age. Hence the second or third instar could be used for field releases to control the target pest. A mean of 77.3 eggs or 35.2 larvae (1.3 day old) of *H. armigera* was the average daily consumption during the development of predator. LINGREN *et al.* (1968) have reported that *C. carnea* larvae consumed 42.7 eggs or 48.8 first instar larvae of *Heliothis* spp. per day.

Development of the first, second and third instars of the predator took 3.00, 2.15 and 3.45 days respectively on the egg diet and 4.80, 2.10 and 4.80 days respectively on the larval diet (Table 2). A total of 8.60 days was required for the predator to complete its development on the egg diet whereas it took 11.70 days on the larval diet. The prolonged development on the larval diet may be due to the fact that the quality of the food available from 1-3 day old larvae developed on artificial diet is less suitable and nutritive than the eggs. Similar results were reported by EL-DAKROURY *et al.* (1979) on *C. carnea* fed with *H. armigera*. Nevertheless, there was not much difference in the pupal period, whether eggs or larvae were used.

Acknowledgements: The authors are grateful to Mr. B. MANOHAR and Mr. C. GOPALAKRISHNAN, Technical Assistants for their assistance throughout the study, and to Dr. (Mrs.) SUDHA NAGARKATTI, Senior Scientist S—3 (Agril. Ento), National Centre for Biological Control, Bangalore, for critically going through the manscript. They are also thankful to K. L. CHADHA, Director, Indian Institute of Horticultural Research, Bangalore for his encouragement and facilities provided.

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EFFICACY AND ECONOMICS OF CERTAIN INSECTICIDES USED FOR THE CONTROL OF SORGHUM SHOOTFLY *ATHERIGONA SOCCATA* (RONDANI) AND STEM BORER *CHILO PARTELLUS* (SWINHOE)[1]

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(Received 31 August 1982)

Field trial was conducted to assess efficacy of promising insecticides for the control of sorghum shootfly and stem borer and to work out the economics of using the different combinations for the control of two pests. Seed germination was found to be generally better in the insecticidal treatments compared to control. Foliar application of decamethrin was relatively less effective than other insecticides for the control of shootfly while aldicarb 10G proved to be slightly more effective. Except malathion dust, other insecticides reduced the borer damage significantly. The cost benefit ratio was found to be highly favourable in the case of carbofuran 5% seed treatment + phenthoate followed by carbofuran 5% seed treatment + endosulfan 4G.

(Key words: Sorghum shootfly, stem borer, efficacy, cost benefit ratio)

INTRODUCTION

The high yielding hybrids and varieties of sorghum, developed by using the exotic parents have proved to be susceptible to insect pests. It has been seen that without effective control, the damage is generally high resulting in substantial loss of grain and fodder. It is recognised that the major thrust in the field of chemical control for sorghum should be to screen and identify insecticides and their formulations which should be effective, easily available, economical and should not leave any toxic residues in grain or fodder.

A number of research papers have been published recently on the efficacy of different insecticides of the control of either shootfly or stem borer (JOTWANI *et al.*, 1977; JOTWANI, 1979; SRIVASTAVA & JOTWANI, 1981). The present investigations were undertaken to assess the efficacy of different combinations of such insecticides for checking the damage by these two pests, determine possible benefit in the form of increase in grain and fodder yields and calculate the cost-benefit ratio for each combination. Decamethrin, one of the recently developed and highly potent synthetic pyrethroids was also included in the trials to determine if it can effectively control the shootfly when applied as foliar spray.

MATERIALS AND METHODS

The experiment was planned on the basis of data collected from preliminary trials on the chemical control of shootfly and stem borer. The trial was conducted in the farm area of the Indian Agricultural Research Institute in *Kharif* 1979, using two high yielding sorghum hybrids *viz.*, *CSH-1* and *CSH-5*. The trial was laid out

[1]A part of the Ph.D. thesis of the first author, submitted to the Post-Graduate School, Indian Agricultural Research Institute, New Delhi 110 012.

in split plot design with eight main treatments (insecticides) and two sub-treatments (hybrids), each treatment was replicated three times. A sub-plot consisted of 4 rows, each row 3 m long, row to row and plant to plant distances were kept at 75 cm and 15 cm respectively.

The following insecticides were selected on the basis of their efficacy determined in earlier trials:

	Shootfly	Stem borer*
T_1	Carbofuran 50 S P seed treatment @ 5 parts/100 parts of seeds	Phenthoate 2% dust
T_2	Carbofuran 3G @ 2.0 g/m row (in seed furrows)	Endosulfan 4% dust
T_3	Fensulfothion 5G @ 3.0 g/m row (in seed furrows)	Carbofuran 3G
T_4	Isofenphos 5G 3.0 g/m row (in seed furrows)	Carbaryl 4G
T_5	Aldicarb 10G @ 1.5 g/m row (in seed furrows)	Carbaryl 5% dust
T_6	Decamethrin 2.5% @ 25ml ai/ha (three applications at an interval of one week beginning five days after germination of seeds)	Malathion 5% dust
T_7	Carbofuran 50 S P seed treatment @ 5 parts/100 parts of seeds	Endosulfan 4G
T_8	Control	No treatment

* Three applications were given in the leaf whorls on 20th, 30th and 40th days after germination @ 8, 10 and 12 kg/ha, respectively.

For shootfiy control, granular insecticides were applied in seed furrows at the time of sowing, with special graduated glass applicators fabricated for this purpose. Care was taken to see that the seed should not come in direct contact with granules. The seed was coated with carbofuran (5% w/w) by adopting the same procedure as described by JOTWANI SUKHANI (1968).

Observations were recorded on seed germination after seven days of sowing, dead hearts caused by shootfly up to 28th day after germination, dead hearts caused by the stem borer up to 40th day after germination, stem tunnelling caused by the borer up to the time of harvest and grain and fodder yields per plot, from which yield in quintals per hectare and increase in yield over control were calculated. The data were subjected to analysis of variance and are presented in Tables 1 and 2.

RESULTS AND DISCUSSION

The germination in different insecticidal treatments was generally found to be better than control but statistically the differences were found to be significant only in the case of *CSH-1*, in which the germination in untreated seeds was lower as compared to *CSH-5*. The differences in response to insecticides between *CSH-1* and *CSH-5* suggest that the physiological state of seeds may be contributing towards the improved germination by the insecticides. However, role of these insecticides in checking damage by harmful soil microflora and fauna cannot be ruled out, especially in the case of insecticides like carbofuran and aldricarb which have fungicidal and nematicidal properties also (SINGH & PRASAD, 1974; THOBBI *et al.*, 1979).

Dead hearts caused by the shootfly maggot has been accepted as a standard

TABLE 1. Shootfly and stem borer damage in different insecticidal treatments.

Tr No	Treatment	Dose ai/ha	% germination of seed		Av. % dead hearts due to shootfly 28 days after germination		Av. % dead hearts due to stem borer 40 days after germination		Av. % stem tunnelling due to stem borer	
			CSH-1	*CSH-5*	*CSH-1*	*CSH-5*	*CSH-1*	*CSH-5*	*CSH-1*	*CSH-5*
T_1	Carbofuran 50 S P (50% S T) + Phenthoate 2% dust	0.4 0.6	61.33 (51.59)	62.00 (51.97)	7.03 (14.33)	17.50 (24.34)	0.43 (2.30)	0.00 (0.18)	17.60 (24.50)	9.10 (17.02)
T_2	Carbofuran 3G @ 2.0 g/m row + Endosulfan 4% dust	0.8 1.2	70.00 (56.99)	67.33 (55.28)	7.47 (14.50)	11.23 (19.35)	0.00 (0.18)	0.00 (0.18)	15.77 (23.26)	6.00 (13.80)
T_3	Fensulfothion 5G @ 3.0 g/m row Carbofuran 3G	2.0 0.9	70.00 (56.81)	70.00 (57.19)	8.33 (15.93)	7.07 (14.33)	0.47 (2.39)	0.50 (2.47)	10.53 (16.61)	12.97 (19.86)
T_4	Isofenphos 5G @ 3.0 g/m row + Carbaryl 4G	2.0 1.2	68.66 (55.96)	74.66 (60.00)	7.07 (14.85)	5.80 (13.56)	1.77 (6.31)	0.90 (3.27)	7.73 (14.78)	7.73 (15.99)
T_5	Aldicarb 10G @ 1.5 g/m row + Carbaryl 5% dust	2.0 1.5	68.00 (55.57)	62.66 (52.40)	0.80 (4.25)	2.90 (7.90)	1.67 (6.13)	1.27 (5.28)	10.37 (18.69)	10.80 (18.70)
T_6	Decamethrin 2.5% @ 0.076 ml/m row + Malathion 5% dust	0.075 1.5	—	—	25.37 (30.13)	31.63 (33.98)	3.30 (5.38)	3.70 (10.78)	16.90 (23.59)	6.37 (13.34)
T_7	Carbofuran 50 S P 50% S T + Endosulfan 4G	0.4 1.2	—	—	12.03 (19.86)	17.47 (24.43)	0.00 (0.18)	0.57 (2.62)	6.40 (11.73)	3.57 (8.61)
T_8	Control		50.66 (45.38)	64.77 (53.83)	65.40 (54.13)	71.63 (58.02)	12.77 (20.59)	13.10 (21.03)	18.63 (25.34)	14.13 (22.08)
'F' test			Sig	N S	Sig	Sig	Sig	N S	N S	Sig
S Em±			(2.29)	(0.89)	(2.98)	(0.94)	(1.23)	(0.78)	(3.33)	(1.12)
C D at 5% level			(7.22)	—	(9.05)	(2.83)	(3.74)	—	—	(3.35)
C D at 1% level			—	—	(12.56)	—	(5.18)	—	—	—

TABLE 2. Yield of grain and fodder in different insecticidal treatments.

Tr No	Treatments	Average yield (q/ha)				Increase over control				Cost benefit ratio	
		Grain		Fodder		Grain		Fodder			
		CSH-1	*CSH-5*	*CSH-1*	*CSH-5*	*CSH-1*	*CSH-5*	*CSH-1*	*CSH-5*	*CSH-1*	*CSH-5*
T_1	Carbofuran 50 S P + 5% S T + Phenthoate 2% dust	60.54	63.84	155.56	185.19	29.72	20.96	70.37	88.89	1:6.62	1:5.21
T_2	Carbofuran 3G @ 2.0 g/m row + Endosulfan 4% dust	60.58	67.23	159.26	177.78	29.76	24.35	74.07	81.48	1:2 37	1:1.95
T_3	Fensulfothion 5G @ 3.0 g/m row + Carbofuran 3G	66.73	71.53	148.14	214.81	35.91	28.65	62.95	118.51	1:1.30	1:1.22
T_4	Isofenphos 5G @ 3.0 g/m row + Carbaryl 4G	74.02	77.75	159.26	229.63	43.20	34.87	74.07	133.33	1:3.58	1:3.37
T_5	Aldicarb 10G @ 1.5 g/m row + Carbaryl 5% dust	72.81	62.73	166.67	211.11	41.99	19.85	81.48	114.81	1:3.12	1:1.59
T_6	Decamethrin 2.5% @ 0.076/ml/m row + malathion 5% dust	51.07	57.82	122.22	140.74	20.25	14.94	37.03	44.44	1:0.32	1:0.07
T_7	Carbofuran 50 S P 5% S T + Endosulfan 4G	65.12	62.09	155.55	174.07	34.30	19.21	70.36	77.77	1:3.88	1:2.20
T_8	Control	30.82	42.88	85.19	96.30	—	—	—	—	—	—
'F' test		Sig	NS	Sig	Sig						
S Em±		5.69	1.57	13.54	4.90						
C D at 5% level		17.25	—	41.07	14.69						
C D at 1% level		23.94	—	56.86	20.18						

parameter for evaluating the efficacy of different insecticides against the fly. In the present studies the percentage dead hearts was found to be significantly less in all the insecticidal treatments as compared to check. Between the insecticides, aldicarb 10G applied @ 1.5 g/m row showed significantly less damage than other treatments while plots receiving decamethrin foliar spray had significantly more damage than the other insecticidal treatments. Between the two hybrids, *CSH-1* and *CSH-5*, carbofuran seed treatment was less effective when applied on *CSH-5*, similarly shootfly damage in decamethrin treatment was also higher on *CSH-5*. This can possibly be due to better plant growth of *CSH-5* as compared to *CSH-1*.

The data given in Table 1 further show that in carbofuran seed treatment the dosage used was 0.4 kg a i/ha as against 2.0 kg a i/ha of fensulfothion, isofenphos and aldicarb. Thus carbofuran seed treatment can be claimed to be much more effective than the other insecticides where the dosage used was five times higher. The new synthetic pyrethroid decamethrin was used at the recommended dose of 0.025 kg a i/ha. The efficacy of this insecticide can possibly be improved by using higher dose, however, this may prove to be uneconomical. The unsatisfactory performance of decamethrin supports the earlier observations that the conventional method of foliar application of insecticides generally proves to be ineffective to control the shootfly especially when the incidence of the pest is moderately high (CHACHORIA, 1972).

The stem borer damage as indicated by dead hearts caused up to 40 days after germination showed significant difference between the insecticides and control in the case of *CSH-1* but not in *CSH-5*. Endosulfan granules as well as dust proved to be more effective than other insecticides when applied on *CSH-1* as well as *CSH-5* while malathion and carbaryl proved to be less effective than other insecticides.

Data on stem tunnelling caused by the borer show (Table 1) that the incidence of the borer was low and the maximum tunnelling was caused in control and minimum in endosulfan 4G, however, the difference was statistically significant in *CSH-5* only. The stem tunnelling was found to be rather high in phenthoate (2%), endosulfan (4%), carbofuran (5%), malathion (5%) dust and carbofuran 3G in *CSH-1* as well as phenthoate, carbofuran and carbaryl in *CSH-5*. In earlier trials these insecticides had given effective control of the borer. It is possible that some of this damage was caused at the late growth stage after the emergence of the earheads. It has been shown that borer damage at the late stage causes very little reduction in the yield. The insecticides in which the borer damage was effectively checked even upto late stage were endosulfan and carbaryl 4G in *CSH-1*, while in *CSH-5* endosulfan 4% dust and malathion 5% dust also proved to be effective. The borer damage was slightly higher in *CSH-1* as compared to *CSH-5*. It is also indicated that efficacy of phenthoate, endosulfan dust and granules and malathion dust to control borer was more when applied on *CSH-5* than on *CSH-1*.

The data on grain and fodder yields given in Table 2 show significant differences in the yield of grain as well as fodder in the case of *CSH-1*. The maximum yield in the insecticidal treatments was about 74.0 q/ha as against 30.30 q/ha in the control. Between the insecticides

isofenphos + carbaryl 4G and aldicarb + carbaryl 5% dust proved to be superior to decamethrin + malathion dust which showed the minimum yield of 51.07 q/ha.

In *CSH-5*, though statistically the differences between insecticidal treatments and control were not significant, numerically the differences were very high. The maximum yield in isofenphos + carbaryl 4G was about 77.8 q/ha as against 42.9 q/ha in control. In this hybrid also, the minimum yield in the insecticidal treatments was in decamethrin + malathion 5% dust.

The yield of fodder showed the same trend and the differences between the insecticidal treatments and control were highly significant.

The data on yield show the same trend as the damage by shootfly and the stem borer, the yields from control being the minimum followed by decamethrin + malathion treatment in which damage by both the shootfly as well as stem borer was high.

The final evaluation about the relative efficacy of different combinations of the insecticides used for shootfly and stem borer control can be made from the extent of increase in yield over control. The maximum average increase in yield of grain of the two hybrids was in isofenphos + carbaryl 4G treatment followed by fensulfothion + carbofuran 3G > aldicarb + carbaryl 5% dust > carbofuran 3G + endosulfan 4% dust > carbofuran 5% ST + endosulfan 4G > carbofuran 5% S T + phenthoate 2% dust > decamethrin + malathion 5% dust. This increase in yield over control is, however, not the sole criterion on which overall efficacy can be assessed. The cost of insecticide and application has also to be taken into consideration along with the monetary benefit from the increased yield of grain and fodder. Cost benefit ratio (CBR) has been worked out for all the insecticides and the values are given in Table 2. The CBR for different insecticidal applications indicates that the ratio is highest in the case of carbofuran 50 SP + phenthoate dust followed by carbofuran 50 SP + endosulfan 4G. The CBR in the case of costlier granular insecticide like isofenphos and aldicarb has also been found to be quite favourable. The CBR is seen to be higher in *CSH-1* than in *CSH-5*. This can be attributed to the higher susceptibility of *CSH-1* to shootfly and stem borer attack as compared to *CSH-5*.

On the basis of these results it can be claimed that under moderate to heavy levels of shootfly and stem borer infestation it will be highly profitable to use carbofuran seed treatment for shootfly control, as recommended by JOTWANI & SUKHANI (1968) along with any of the other insecticide like phenthoate, endosulfan, carbaryl dust or endosulfan granules for the control of stem borer.

Acknowledgement: The authors are grateful to the Head of the Division Entomology, Indian Agricultural Research Institute, New Delhi for providing necessary facilities to carry out the present investigations.

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Entomon, 1982, *Vol.* 7, *No.* 3, *pp.* 397 *to* 401

TETRANYCHOID MITES INFESTING FRUIT TREES IN THE PUNJAB TOGETHER WITH RECORDS OF SOME NEW HOSTS AND DESCRIPTION OF A NEW SPECIES

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(Received 14 June 1981)

Seventeen species of Tetranychid mites of fruit trees are reported from the Punjab State. *Tetranychus cinnabarinus* (Boisduval), *Terminalichus karachiensis* Hnwarullah & Khan, *Brevipalpus obovatus* Donnadieu, *B. phoenicis* (Geijskes) and *B. rugulosus* Chaudhri, Akbar and Rasool are reported on new host-plants. *Brevipalpus rugulosus* Chaudhri, Akbar and Rasool is reported for the first time on fruit tree. A new species of the genus *Tenuipalpus* Donnadieu is described and illustrated.

(Key words: Tetranychoid mites, fruit trees, Punjab, new species, new hosts)

INTRODUCTION

Our knowledge of tetranychoid mites infesting fruit trees in the Punjab is rather incomplete. Whatever little we know about them is due to the work of Sethi *et al.*, 1964; Bindra, 1966; Sethi, 1967; Gupta *et al.*, 1971; Gupta and Dhooria, 1972; Sadana and Kanta, 1972; Sadana and Chander, 1974; Sadana and Chhabra 1980 a, b, c and d; Dhooria and Sandhu, 1973; Gupta, 1976 and Sadana and Joshi, 1976. During the present investigations, we have encountered seventeen species of tetranychoid mites infesting fruit trees in the Punjab, of which, seven species belong to the family Tetranychidae and ten to the family Tenuipalpidae. A new species of genus *Tenuipalpus* was also encountered and the same is described here.

Brevipalpus rugulosus Chaudhri, Akbar and Rasool has been recorded for the first time on fruit tree. Four of the hitherto known tetranychoid mites of the fruit trees in the Punjab viz. *Bryobia praetiosa* Koch, *Panonychus citri* (McGregor), *Eotetranychus truncatus* Estebanes and Baker and *E. suginamensis* (Yokoyama) were not encountered during the present studies. Many new host plants have also been encountered which are marked with asterisks in the text. *Punica granatum* Linn., *Zizyphus jujuba* Linn, *Morus alba* Linn., *Eriobotrya japonica* Lindl., *Vitis vinifera* Linn., *Psidium guajava* Linn., *Prunus persica* (Linn.) Stokes *Citrus* sp., *Achras zapota* Linn., *Musa paradisiaca* Linn., *Mangifera indica* Linn., *Pyrus communis* Linn., and *Carica papaya* Linn., were found to harbour more than one mite species whereas *Ficus carica* Linn, *Litchi chinensis* Sonner, *Prunus cerasifera* Ehrh, and *Phoenix dactylifera* Linn. were found to be infested with just one species each. With the addition of the present records to the existing information, the total number of tetranychoid mites infesting fruit trees in the Punjab now stand at twenty one.

The mite species encountered during the present study are listed below along with their collection data.

Family Tetranychidae

1. Eutetranychus orientalis (Klein)

Collection data: 3 ♀♀, 2 ♂♂, INDIA: Ludhiana, PAU Campus (Punjab Agricultural University), on *Zizyphus jujuba* Linn., 28.viii.1978, Coll. Kesar Singh; 4 ♀♀, 1 ♂, Abohar on *Prunus persica* (Linn.) Stokes, 4.vii.1978, 10 ♀♀, 4 ♂♂, Abohar, on *Carica papaya* Linn., 5. vii. 1978, Coll. S. C. Chhabra; 17 ♀♀, 12 ♂♂, Jagraon, on *Citrus medica* var. *limonum* Linn., 25.v.1978, Coll. Bimal Kumar.

2. Eotetranychus hirsti Pritchard & Baker

Collection data: 14 ♀♀, 1 ♂, INDIA: Ludhiana, Habowal, on *Ficus carica* Linn., 28.vi.1978, Coll. Bimal Kumar.

3. Eotetranychus fremonti Tuttle & Baker

Collection data: 2 ♀♀, INDIA: Morinda, on *Morus alba*, Linn., 20.vii.1978, 4 ♀♀, 1 ♂, Ludhiana, 13. xii. 1978, Coll. Bimal Kumar; 22 ♀♀, 6 ♂♂, Ludhiana, Kathori, on *Zizyphus jujuba* Linn., 18.ii.1979, Coll. Kesar Singh.

4. Oligonychus mangiferus (Rahman and Sapra)

Collection data: 2 ♀♀, 1 ♂ INDIA: Ludhiana, on *Vitis vinifera* Linn., 25.vi 1978, 1 ♂ Fazilka, 3.vii 1978, Coll. S. C. Chhabra; 2 ♀♀, Ludhiana, on *Mangifera indica* Linn., 5.xi.1978, Coll. Kesar Singh, 1 ♀, 1 ♂, Amritsar, Harike, Coll. S. C. Chhabra; 10 ♀♀, 2 ♂♂, Ludhiana, on *Eriobotrya japonica* Lindl. 23.vi.1978, Coll. Kesar Singh.

5. Oligonychus punicae (Hirst)

Collection data : 2 ♀♀, 1♂, INDIA: Jagraon, on *Litchi chinensis*. Sonner, 25.vi.1979, Coll. Bimal Kumar.

6. Tetranychus cinnabarinus (Boisduval)

Collection data : 3 ♀♀, 3 ♂♂, INDIA: Ludhiana, on *Zizyphus jujuba** Linn., 15.xii.1978, 7 ♀♀, 3 ♂♂, Ludhina, on *Musa paradisiaca** Linn., 15.xii.1978, 11 ♀♀, Ludhiana, on *Mangifera indica* Linn. 25.xii.1978, Coll. Kesar Singh; 37 ♀♀, 15 ♂♂, Ludhiana, Habowal, on *Morus alba* Linn., 28.vi.1978, 1 ♀, Ludhiana, Ladhowal, *Vitis vinifera* Linn., 23.vi.1978, 2 ♀♀, 2 ♂♂, Ludhiana, on *Prunus cerasifera** Ehrh, 5.xii.1978, 2 ♀♀, 1 ♂, Fazlika, 24.vi.1978, Coll. S. C. Chhabra.

7. Aponychus sulcatus Chaudhri

Collection data : 1 ♀, INDIA: Ferozepur, on *Carica papaya* Linn., 28.vi.1978, Coll. S. C. Chhabra.

Family Tenuipalpidae

8. Terminalichus karachiensis Anwarullah & Khan

Collection data: 3 ♀♀, INDIA: Ludhiana PAU Campus, on *Psidium guajava** Linn., 5.i.1979, Coll. S. C. Chhabra.

9. Raoiella indica Hirst

Collection data : 8 ♀♀, 2 ♂♂, INDIA: Ludhiana, Phalenpur Gujran, on *Phoenix dactylifera* Linn., 23.vi.1978, Coll. Bimal Kumar.

10. Brevipalpus obovatus Donnadieu

Collection data : 29 ♀♀, INDIA: Ludhiana, on *Zizyphus jujuba** Linn., 15.viii.1978, 1 ♀, Ludhiana, on *Achras zapota** Linn. 9.xi.1978, Coll. Kesar Singh; 3 ♀♀, Ludhiana, on *Eriobotrya japonica* Lindl. 23.vi.1978, Coll. Bimal Kumar.

11. Brevipalpus phoenicis (Geijskes)

Collection data: 1 ♀, INDIA; Ludhiana, Pakhowal, on *Vitis vinifera* Linn., 21.vii. 1978; 10 ♀♀, Muketsar, 26.xi.1978, 5 ♀♀, 1 ♂, Ludhiana, PAU Campus, on *Psidium guajava* Linn. 4.ix.1978, 3 ♀♀, Ludhiana, Jandiali, 6.iv.1979, 5 ♀♀, Morinda, 25.vii. 1978, 6 ♀♀ Beas, 29 xii.1978. 2 ♀♀, Ludhiana, on *Achras zapota** Linn., 28.xi.1978, 1 ♀ Ludhiana, Siahar, on *Punica grantum*

Linn., 4.x.1978, 14♀♀ and 5 ♀♀, Ludhiana, Birma, on *Morus alba** Linn., and *Zizyphus jujuba** Linn., 15.viii.1978, 8 ♀♀, Ludhiana, Pakhowal, on *Eriobotrya japonica** Lindl., 6.viii.1978, 2 ♀♀, Jullundur, 7.x.1978, Coll. Kesar Singh; 2 ♀♀, Ludhiana, PAU Campus, on *Prunus persica** (Linn.) Stokes, 26.x 1978, 4 ♀♀, Ludhiana, on *Musa paradisiaca* Linn., 8.i.1979, Coll. Bimal Kumar; 1 ♀, Ropar, on *Mangifera indica* Linn., 25.xii.1978, 11 ♀♀, Ludhiana, PAU Campus, on *Pyrus communis* Linn., 28.xi. 1978, Coll. S. C. Chhabra.

12. Brevipalpus rugulosus Chaudhri, Akbar & Rasool

Collection data: 3 ♀♀, INDIA: Abohar, on *Carica papaya** Linn., 5.vii.1978, Coll. S. C. Chhabra.

13. Brevipalpus karachiensis Chaudhri, Akbar & Rasool.

Collection data: 2 ♀♀, INDIA: Ludhiana, Ladhowal, on *Musa paradisiaca* Linn., 23.vi.1978, Coll. Bimal Kumar.

14. Tenuipalpus aboharensis Sadana & Chhabra

Collection data: 5 ♀♀, INDIA: Abohar, on *Punica granatum* Linn., 4.vii.1978, Coll. S. C. Chhabra.

15. Tenuipalpus punicae Pritchard & Baker

Collection data: 13 ♀♀, INDIA: Jagraon, on *Punica granatum* Linn., 25.vi.1978, 19 ♀♀, Ferozepur, 28.vi.1978, 5 ♀♀, Fazlika, 3.vii.1978, 9 ♀♀, Ropar, 25.vii.1978, Coll. S. C. Chhabra; 6 ♀♀, 1 ♂, Ludhiana, Siahar, 17.ix.1978, 23 ♀♀, Ludhiana, Kullahar, 21.xii.1978, Coll. Kesar Singh.

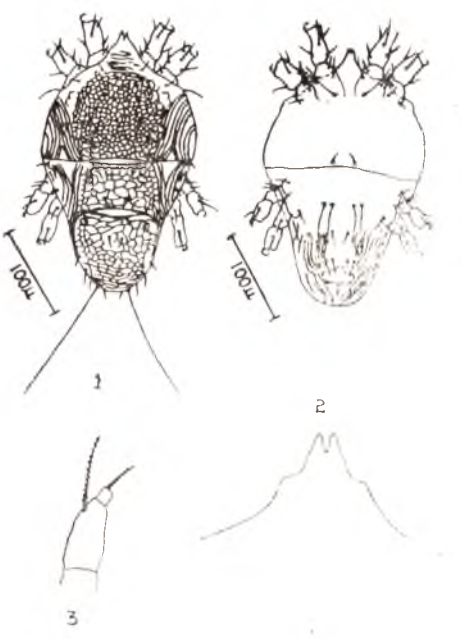
16. Tenuipalpus ludhianaensis Sadana & Chhabra

Collection data : 7 ♀♀, INDIA: Ludhiana on *Pyrus communis* Linn,, 10 xi.1978, Coll. Kesar Singh.

[1]All measurements expressed in μm unless otherwise stated.

17. Tenuipalpus persicae sp. nov.

Female: Body 245—255[1] long (without rostrum) and 150—170 wide. Rostral shield deeply notched, reaching upto the proximal end of femora-1, with a small and a prominent lobe on each side. Palpus 3 segmented, 2nd segment with a



Figs. 1—4. *Tenuipalpus persicae* sp. nov. 1. Dorsal view (legs legs partially shown); 2. Ventral view (legs partially Shown;) 3. Left palpus; Rostral shield.

long, serrate seta, terminal segment with a rod-like sensory seta. Propodosoma with reticulations medially and marginally directed striations laterally. Propodosomal setae 3 pairs, slender, serrate measuring 5—6, 25, 3.75—5 and 18.75—26.25 long respectively. Eyes 2 pairs, 1 pair on each side. Humeral setae 1 pair, each seta 7.5—8.75 long. Hysterosoma reticulated with large sized cells, a few striations present anterolaterally. A transverse non-reticulated band separates metapodosoma and opisthosoma. The latter with a pair

of pores. Central setae 3 pairs, measuring 6.25—8.75, 6.25—7.5 and 6.25—8.75 respectively. Lateral setae 6 pairs, serrate, I minute, II, III, IV and VI being 7.5—10, 10—11.25, 10—11.25 and 7.5—10 long respectively. V seta flagellate and largest of all being 80—100 long. Seta II much shorter than the distance between II and III.

Propodosoma without striations ventrally. Medioventral propodosomal setae 1 pair, long, simple measuring 41.25—60; anterior medioventral metapodosomal setae 1 pair, 7.5—10 long; posterior medioventral metapodosomal setae 2 pairs, simple, outer 40—50 long and inner 35—40 long, crossing the bases of ventral shield setae; ventral shield setae 1 pair each measuring 15—25; genital shield setae 2 pairs, each seta 15—20 long. Anal setae 2 pairs. Legs 4 pairs, segments wrinkled. Setae on legs I—IV, coxae 2-2-1-1, femora, 4-4-2-1, genua 1-1-0-0, tibiae 5-5-3-3. Setae on tarsi not clear.

Male: Not known.

Holotype: ♀ (marked on slide No. 4), INDIA: Punjab, Ludhiana, PAU campus, on *Prunus persica* (Linn.) Stokes, 27.vi.1978. Coll. Bimal Kumar.

Paratypes: 3 ♀♀ (slide No. 5), same data as for holotype.

Repository: The holotype and paratypes are housed in the Acarological collections of the Department of Zoology, Punjab Agricultural University, Ludhiana but will be deposited in the National Pusa Collection, I. A. R. I., Delhi in course of time.

Remarks: The present species resembles *T. pyrusae* Maninder & Ghai, but differs from it in the setal pattern on femora IV and tibiae I & II. Femora IV and tibiae I & II each possess 2 and 4, 4 setae in *T. pyrusae* whereas in the new species only 1 and 5, 5 are present on each of these segments. It also resembles *T. dimensus* Chaudhri, but differs in having dorsolateral seta II shorter than the distance between setae II and III.

Acknowledgements: The authors are thankful to Dr. S. S. Guraya, Professor and Head, Department of Zoology, Punjab Agricultural University, Ludhiana for laboratory facilities and I. C. A. R. for financing the scheme to carry out the taxonomic work on tetranychoid mites. The help rendered by Mr. Kesar Singh is gratefully acknowledged.

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BRIEF COMMUNICATION

THE ROOSTING BEHAVIOUR OF *CHALYBION BENGALENSE* DAHLBOM (SPHECIDAE : HYMENOPTERA)

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(Received 21 June 1982)

The roosting behaviour of the solitary sphecid wasp *Chalybion bengalense* is described as observed in the Calicut University campus, under tropical conditions. A discussion on the significance of the communal roosting behaviour of this and related wasps is given.

(Key words: *Chalybion bengalense*, Sphecidae, roosting behaviour)

The habit of gathering to common roosts in which to sleep generally by night is seen in some genera of sphecid wasps. Individuals of *Chalybion bengalense* Dahlbom (sub-family Sphecinae) which hunt for spiders and are familiar wasps in human habitations, form roosting aggregations varying from a few to over thirty individuals. JAYAKAR & MANGIPUDI (1964) gave an account of the dormitories or sleeping aggregations of this wasp under the subtropical conditions of Bhubaneswar, Orissa, during October to November, 1963, centered round the fifth and sixth links in the middle part of an iron chain of a lavatory cistern. The individuals which formed the roost consisted of both female and male wasps and considerable overlapping was noted in their positions in the aggregation. The wasps always clung to the chain in a vertical position, almost always facing upwards.

Under the tropical conditions in South-West India, it is for the first time that observations on the roosting aggregations of *C. bengalense* are being reported. In the Calicut University campus in the author's quarters (B-2) during the year 1974—75, the two locations selected by this wasp for roosting were: 1) on the garden plant *Fittonia verschaffetii* grown in suspended flower pot on the leaves (Fig. 1) of branches hanging down along the sides of the pot; 2) on hanging cords (Fig. 2). Both these locations were in sheltered places on the verandah. Such aggregations were noticed during the two periods of the year (March to June and August to November) when the populations of this wasp were large. The roosting individuals consisted of both females and males which did not remain in a cluster, but in a fairly loose aggregation without maintaining physical contact or doing so as little as possible. The individual wasps usually started arriving at the roost about two to one and a half hours before sunset. Before finally settling down on the roost, often a flight manoeuvre was held, with individuals exchanging places or taking up new places. After the overnight sleep, the individuals usually started dispersing within about two hours after sunrise. No case of mating was ever observed at the roosts. When two roosting aggregations remain close to each other (Fig. 2), it would be interesting to observe whether the same group of individuals

always or usually formed a particular aggregation or whether the roosting is done at random. This can easily be verified by marking a few individuals in each aggregation (after the settling down of the individuals in a roost) with differently coloured paints and noting day after day the positions taken by the marked individuals in the two aggregations.

What is the significance of the roosting behaviour of *C. bengalense* and related wasps in which the aggregations are always formed of female and male individuals? In *Steniolia obliqua* (sub-family Nyssoninae), one of the North American fly-catcher wasps, very large numbers of individuals roost in a close cluster, the females tending to form tight balls in the middle with the males on the outside (EVANS & GILLASPY, 1964). Matings occurred not infrequently in and about the clusters and the only likely suggestion as to their significance is that such roosting aggregations are concerned with mating behaviour (ANDREWES, 1969). On the other hand, for the roosting aggregations of *Chalybion caeruleum* (JOHANSSEN & LINNAEUS) (now *californicum* Sassure) observed by RAU & RAU (1916) in Kansas, they could give no satisfactory explanation for this assembly at which though males and females were present in almost equal numbers, they were convinced that mating never occurred. EVANS & LINSLEY (1960) suggested that such aggregations may provide protection from predators. But this idea is found to be untenable on the basis of the observations of many authors including those of RAU & RAU (1916).

Although various authors have made other suggestions regarding significance of the roosting behaviour in the solitary wasps, the one proposed by WYNE-EDWARDS (1962) appears to be more appealing. According to him, the primary function of the roost in the solitary wasps and other insects is to bring the members of a population unit occupying a given area to a communal roosting territory (or the roosts serve as foci in a territorial system) and provide them with a chance for epideictic (communal) displays to stimulate the adjustment of population density through emigration, when necessary. He thus points out the similarity of the significance of the communal roosting behaviour found in all the three classes of the highly mobile flying animals: the birds, the bats and the insects, as based on the necessities for dispersion. It may, however, be remarked that the correct interpretation

Fig. 1. Two roosts of *Chalybion bengalense* on the leaves of the garden plant *Fittonia verschaffetii*. Fig. 2. Roosting of *C. bengalenes* on hanging cords. Two roosting aggregations are seen.

of the significance of the roosting behaviour in the solitary wasps still defies our imagination.

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Entomon, 1982, *Vol.* 7, *No.* 4, *pp.* 407 *to* 409

BRIEF COMMUNICATION

THE REFLEX FROTH-DISCHARGING BEHAVIOUR IN THE COFFEE LOCUST (*AULARCHES MILIARIS* L.) AS AN ANTI-PREDATOR DEFENSIVE MECHANISM

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(Received 21 June 1982)

When an individual coffee locust was held by its tegminae, by the thorax, or confronted by a potential predatory animal, the reflex discharge of a foul-smelling frothy fluid took place from its mesothoracic spiracles. Soon the two frothy masses grew into large blub-shaped structures which finally enveloped the body of the insect. The role of this reflex forth-discharging behaviour as anti-predator defensive mechanism is discussed

(Key words: Aularches miliaris L., reflex froth-discharging behaviour, anti-predator defensive mechanism)

During June 1975, vast area of the eastern parts of the Malappuram District of Kerala comprising Panthaloor and six other localities involving over a thousand acres of plantations of teak, coconut, arecanut, jack fruit and rubber trees, and pepper plants, were invaded and severely damaged by the coffee locust, *Aularches miliaris* L. (sub-family Pyrgomorphinae, fam. Acrididae) in spite of the very heavy rains of the South-West monsoon season.

A team of entomologists from the Calicut University visited the Panthaloor area to see the swarms of locusts in action. When an individual locust was held by its tegminae or by the thorax, a white frothy fluid started coming out from its mesothoracic spiracles above the base of the mid coxae (Fig. 1). The frothy mass started growing in volume on either side of the insect's thorax. Within a few seconds, the mass of white froth grew into two bulb shaped structures, approximately 5 cm in length and 2.5 cm at their greatest width (Figs. 2 & 3). Finally the mass of froth enveloped almost the whole body surface of the insect.

The large flightless lubber grasshopper *Romalea microptera* (sub-family Romaleinae, fam. Acrididae) of the United States similarly emits froth from its mesothoracic spiracles (EISEN & MEINWALD, 1966) This froth consists of a mixture of the secretion produced by glandular tissue or tracheal gland (that surrounds the highly coiled tracheae associated with the spiracles) and tracheal air. The insect relies on tracheal air pressure to discharge its glandular secretion (EISNER, 1970).

What is the biological role of this reflex froth-discharging behaviour in *A. miliaris*? Especially when the body of this insect is enveloped in the white frothy secretion having a foul smell, this can act as a repellent, making the producer of the froth distasteful or unpalatable for a potential predator. In nature this locust is known to eject the white froth when confronted by a predatory animal. It is also

known that this behavioural adaptation is used with success against certain smaller predators like ants and small birds, but that some large birds and rats are not deterred by the foul smelling secretion with which the insect's body is covered, and they feed voraciously on the locusts.

To find out the nature of the action of the frothy secretion of *A. miliaris* as an anti-predator defensive mechanism, it will be necessary to carry out a number of biochemical tests on the fresh froth obtained from recently captured coffee locusts as was done on the regurgitate of the grasshopper *Goniaea* sp. of Western Australia by LYMERY & BAILEY (1980). Also observations of predator-prey interactions will have to be made in the laboratory and in nature.

In *R. microptera* the only compound so far isolated from its frothy secretion is an allenic sesquiterpenoid (MEINWALD *et al.*, 1968) of unknown defensive merits (EISNER, 1970). The quantity and perhaps the toxicity of the frothy secretion produced in *R. microptera* are much less than in *A. miliaris*. This in itself may probably be due to the fact that *R. microptera* has a much more potent anti-predator defensive mechanism—a large drop of dark fluid "tobacco juice"—in its reflex regurgitation as a last ditch defence (STEINER, 1981).

On the other hand, no reflex regurgitation was found to take place in *A. miliaris* when handled. Thus this locust depends solely on the reflex discharge of its copious frothy secretion (most probably of the tracheal gland) as an anti-predator defensive mechanism which is highly effective in repelling small predators, although it offers no protection against the larger predators.

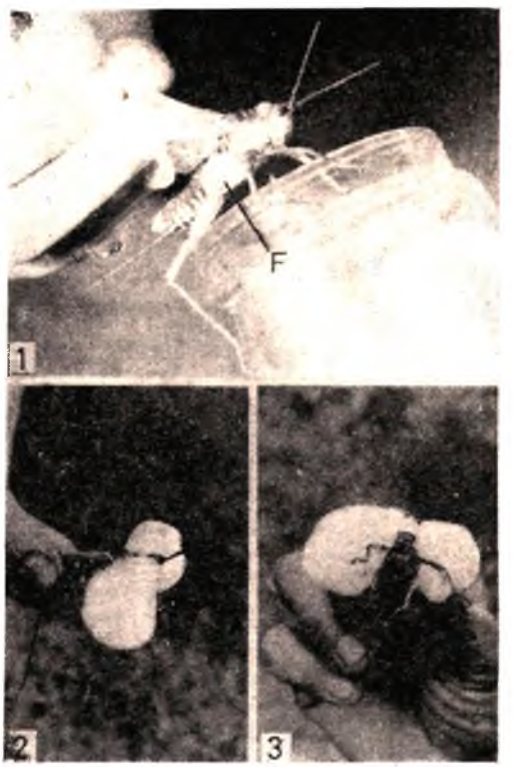

Fig. 1. A specimen of the coffee locust held by its tegminae shows the initial stage of the forth-discharging behaviour. F: Froth. Fig. 2. Further accumulation of forth into bulb-shaped masses. Fig. 3. Later stage showing the large masses of froth beginning to envelope the body surface of the locust.

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Entomon, 1982, *Vol.* 7, *No.* 4, *pp.* 411 *to* 421

UTILIZATION OF CHOLESTEROL BY THE ADULTS OF HOUSE FLY, *MUSCA DOMESTICA*

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(Received 13 February 1982)

The effect of different concentrations of cholesterol in the larval medium on the levels of total phospholipid and sterols present in both sexes of the adult house fly, *Musca domestica*, was studied. The cholesterol and its metabolites of the adults were analysed and the accumulation of these compounds was examined in the ovaries of control insects (raised on 0.56 μmole cholesterol/g of larval diet) maintained on sugar and water for a period of ten days. Alterations made in the concentration of cholesterol in the larval diets did not produce any significant effect on the phospholipid content in both the sexes. However, the ratios of sterol to phospholipid recovered from the lipid fraction increased rapidly when the concentration of cholesterol was raised in larval diets. Similarly adults from deficient dietary cholesterol had less than 3% of the sterol as sterol esters and such adults failed to produce mature ovaries. On the other hand adult flies from control groups showed ovarian development; but the full development occurred when an amino acid mixture was made available to them. The total sterol and protein contents increased markedly on the 3rd day after eclosion of the flies. A continuous increase in the amounts of 7-dehydrocholesterol recovered from such ovaries was observed in 1—10 day old flies. A possible function and utilization of cholesterol by the developing ovaries of the insect are discussed.

(*Key words:* cholesterol, housefly, 7-dehydrocholesterol, oogensis)

INTRODUCTION

The house fly, *Musca domestica*, requires a dietary source of cholesterol for larval growth and development. Studies have indicated that the concentration of larval dietary cholesterol had to be raised to 0.56 μmole/g of diet (optimum concentration of cholesterol) before the maximum number of pupae and adults were obtained (DWIVEDI, 1975). The larvae raised on diets deficient in cholesterol contained a reduced sterol content compared with that of the control insects which were raised on 0.56 μmole cholesterol/g diet. However, cholesterol deficiency did not affect the phospholipid content during either larval or adult stage when it was compared to that of control insects (DWIVEDI, 1976, 1977). An addition of cholesterol to the standard larval diets increased the content of total phospholipid of the pharate adults of the fruit fly, although the phospholipid content was not investigated in both sexes of the insect (CASTILLON *et al.*, 1974).

The requirement for cholesterol as a vital substrate for the embryogenesis of the housefly, *Musca domestica*, has been suggested (ROBBINS & SHORTINO, 1962). Studies on insects which are capable of converting phytosterols into cholesterol

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indicated that the cholesterol rapidly accumulated in the ovary of insects in the beginning of oogenesis with the maximum increase of cholesterol esters during oocyte maturation (GILBERT & GOODFELLOW, 1965; ICHIMASA, 1976). Cholesterol esters and 7-dehydrocholesterol (5, 7-cholestadien-3β-ol) are the primary metabolic products of cholesterol during the life cycle of the house fly although neither metabolite apparently occurs in significant amounts during the larval stage of the insect (ROBBINS *et al.*, 1971; DWIVEDI, 1975). 7-dehydrocholesterol has been implicated as the first step in the biosynthetic pathway of ecdysones from cholesterol (GALBRAITH *et al.*, 1970; SVOBODA *et al*, 1975). The presence of 7-dehydrocholesterol in the insects reared under aseptic conditions on diets containing cholesterol has been reported for *Blattela germanica* (ROBBINS *et al.*, 1964), *Calliphora erythrocephala* (JOHNSON *et al.*, 1975), and in the eggs of *Musca domestica* (MONROE *et al.*, 1968). Presumably cholesterol metabolites like cholesterol esters and 7-dehydrocholesterol present in the adult insect may be associated with the development and maturation of the ovaries.

The aim of the present investigation was to identify various sterol metabolites in both sexes of the adult housefly in response to different amounts of cholesterol feeding at the larval stages. The effect of various amounts of dietary cholesterol fed to larvae on the ratios of cholesterol to phospholipid recovered from the lipid fraction of such adult insects were determined. The accumulation of sterol metabolites in the ovaries of the flies developed from the larvae reared on 0.56 μmole cholesterol/g of diet was examined when no exogenous source of cholesterol was available to adult housefly for a period of ten days.

MATERIALS AND METHODS

Materials

Carrier-free (4—^{14}C) cholesterol (sp. act. 157 μCi/mg) in benzene solution was obtained from the Radiochemical Centre, Amersham, England. Silica gel-G from E. Merck, Germany, was usedfor the preparation of thin-layer plates for chromatography. Other chemicals used were of analytical grade.

Rearing of insects

Larvae of the housefly, *Musca domestica*, were reared aseptically on the casein medium as described earlier (DWIVEDY, 1975; 1976). Surface sterilized housefly eggs were added to the medium and larvae were allowed to pupate at 28°C for six days. Newly emerged flies were segregated into males and females. Adults of both sexes were fed on glucose and water for four days before being taken for extraction of lipid. Some of the adult female flies were kept as control (those reared on 0.56 μmole cholesterol/g diet) for ten days on sucrose and water for the examination of cholesterol and its metabolites present in their ovaries.

Extraction and separation of lipids from both sexes of adults and ovaries:

The ovaries were dissected in cold phosphate saline (PRICE, 1968) and isolated without spermatheca and accessory glands. The lipids from both sexes of adults and ovaries were extracted and washed by the methods described previously (DWIVEDY & BRIDGES, 1973; DWIVEDY, 1977).

The free sterol and steryl esters present in the lipid extracts were separated on silica gel-G coated thin layer plates by the method described by FREEMAN & WEST (1966). A successful separation of 7-dehydrocholestol from other sterols as its acetate was achieved by hexane: benzene (1 : 1 v/v) on 20% silver nitrate impregnated silica gel-G thin layer plates according to the method described by JOHNSON *et al.*, (1975). The compounds were detected under U. V. light after separation on thin layer plates and spraying with a 10% (W/V) solution of Rhodamine 6G in acetone. The identity of the extracted 7-dehydrocholesterol was checked by co-chromatography with a standard sample on the thin-layer plates. It was further confirmed by the gas-liquid chromatography after eluting the samples with hexane from thin layer plates and analysing them on a glass column packed

with 3% OV-17 on Diatomite CQ (100—120 mesh) at a temperature of 265C° (JOHNSON *et al.*, 1975). The standard sample of 7-dehydrocholesterol was obtained from the Steroid Reference Collection Centre, Kidderpore Avenue, London,U. K.

The (4—^{14}C) steroid radioactivity was assayed in an Inter-technique Scintillation spectrometer (model ABAC SL—40) using 10.0 ml of scintillation solution (0.3% PPO with scintillation grade xylene). The chemical estimation of phospholipid phosphorus of the lipid extract was made by the procedure of BARTLETT (1959).

Protein determination:

The protein content of the materials left after lipid extraction of the ovaries was determined by the Biuret method (GORNALL *et al.*, 1949).

RESULTS

Effect of larval dietary cholesterol on sterol and phospholipid content in both sexes of adult flies:

The total sterol and phospholipid content extracted from the lipid fraction of male and female adult flies (4 day old) obtained from larvae reared on various amounts of dietary cholesterol are given in Tables 1 and 2 respectively. The sterol content in both the sexes increased rapidly when the amounts of dietary cholesterol was raised up to 0.56 μmole/g diet which represented the control group of flies. However, it increased less than twice the values of control group of insects when the concentration of cholesterol was raised up to twenty times (11.2 μmole/g diet). The housefly larvae reared on low cholesterol (0.05 μmole/g diet) showed a considerable growth although they had approximately 25% of the cholesterol of the larvae reared on control diets (DWIVEDI, 1975). Adults obtained from larvae reared on cholesterol deficient diets contained a sterol content of 55% in male and 35% in female of that present in the adults reared on control diets that is 0.56 μmole cholesterol/g diet. Irrespective of the cholesterol concentration in the larval diets female adults apparently contained a higher amount of total sterol than that observed in male adults ($P < 0.02$).

The phospholipid content of both the sexes of adult flies were not affected significantly on alterations made in dietary cholesterol except a slight ($0.01 < P < 0.02$) decrease in the phospholipid content of female adults.

The molar ratios of sterol to phospholipid increased much more rapidly in the adults from larvae reared on diets up to 0.56 μmole cholesterol/g of diets. The female adults had a higher ratio than males ($P < 0.005$).

Effect of dietary cholesterol on sterol metabolites of adult flies:

The percentage radioactivity recovered as sterol esters from the adult flies on deficient cholesterol was less than 3%; however, it increased rapidly when the cholesterol content of the fly was increased. The percentage was higher in female flies (24%) than that of the male flies (10%) (Tables, 3 and 4).

The percentage of 'polar sterol's appeared to be slightly higher in female flies than that observed in male flies irrespective of dietary concentration of cholesterol (Tables 3 and 4). The nature of the 'polar sterols' was not investigated in the present study.

Sterol and protein contents of female adults and their ovaries:

The total sterol (nmole per insect or per pair of ovaries) and protein (mg/insect or per pair of ovaries) content from the isolated ovaries of the control adult female flies held on sucrose and water over a period of ten days are given in Table 5. It indicates that the total sterol and protein

TABEE 1. Effect of increasing larval dietary concentration of cholesterol on the sterol and phospholipid contents of male adult housefly (4 days post eclosion).

Cholesterol added to the larval diets (μmole/g of diets)	μmole total sterol per mg wet weight of male adult (A)	μmole of lipid phosphorus per mg wet weight of male adult (B)	Sterol/phospholipid ratio (A/B)
0.05	0.80±0.19	22.5±2.4	0.035±0.003
0.28	1.26±0.15	23.2±0.8	0.054±0.010
0.56	1.45±0.20	22.6±3.0	0 064±0.030
1.40	1.61±0.26	25.2±3.0	0.064±0.043
1.95	1.65±0.32	23.3±2.5	0.071±0.015
3.35	1.68±0.18	23.6±2.1	0.071±0.020
5.60	2.10±0.50	25.4±2.4	0.083±0.030
11.20	2.28±0.40	25.7±2.0	0.089±0.041

TABLE 2. Effect of increasing larval dietary concentration of cholesterol on the sterol and phospholipid contents of female adult housefly (4 days post eclosion).

Cholesterol added to the larval diets (μmole/g of diets)	μmole total sterol per mg wet weight of female adult (A)	μmole of lipid phosphorus per mg wet weight of female adult (B)	Sterol/phospholipid ratio (A/B)
0.05	0.64±0.24	21.0±2.2	0.030±0.011
0.28	1.78±0.23	22.8±0.6	0.078±0.013
0.56	1.85±0.10	23.0±2.0	0.080±0.012
1.40	1.93±0.58	23.6±2.7	0.082±0.014
1.95	1.95±0.20	22.6±2.9	0.086±0.015
3.35	1.98±0.50	19.5±1.8	0.102±0.011
5.60	2.05±0.20	18.4±2.7	0.112±0.018
11.20	2.60±0.30	18.9±1.6	0.140±0.020

Results are given as means ± S D of three determinations.

TABLE 3. The percentage of free sterols, sterol esters and polar sterols recovered after separation T L C plates of lipid extract of male adult flies (4 days post eclosion).

Cholesterol added to the larval diets (μmole/g of diets)	Radioactivity at the point of application on TLC	'Polar sterols' (radioactivity between point of application and free sterols) (%)	Free sterols (%)	Sterol esters (%)
0.05	0.3±0.1	2.6±0.1	96.1±0.1	0.9±0.2
0.28	0.2±0.1	1.1±0.4	89.7±0.1	9.1±0.4
0.56	0.4±0.3	1.7±0.5	89.3±2.2	8.6±1.9
1.40	0.9±0.5	1.2±0.2	88.3±3.0	9.7±2.4
1.96	1.1±0.1	1.5±0.4	85.0±2.5	12.4±1.9
3.35	0.9±0.2	2.3±0.8	82.8±1.2	14.0±1.2
5.60	0.8±0.3	2.5±0.5	82.3±1.1	14.6±1.4
11.20	0.9±0.6	2.3±0.8	81.3±1.1	15.5±0.6

Results are given as means ± S D of three determinations.

TABLE 4. The percentage of free sterols, sterol esters, and polar sterols recovered after separation on T L C plates of lipid extract of female adult flies (4 days post eclosion).

Cholesterol added to the larval diets (μmole/g of diets)	Radioactivity at the point of application on TLC (%)	'Polar sterols' radioactivity between point of application and free sterols) (%)	Free sterols (%)	Sterols esters (%)
0.05	1.7±0.3	3.5±0.7	92.7±1.4	2.1±0.7
0.28	1.0±0.2	2.7±0.5	73.1±0.9	23.2±0.8
0.56	0.9±0.5	3.0±0.4	73.4±3.1	22.7±2.5
1.40	0.8±0.6	2.7±1.0	71.3±3.0	25.2±1.2
1.95	1.1±0.2	2.1±0.6	71.2±3.1	25.7±1.5
3.35	1.2±0.3	4.1±0.9	67.2±2.5	27.6±3.1
5.60	1.2±0.5	3.9±1.0	68.1±1.5	26.8±1.8
11.20	0.9±0.2	2.5±0.3	69.4±1.2	27.2±2.3

Results are given as means ± S D of three determinations.

TABLE 5. The weight, total sterol, and protein contents of female adults and isolated pairs of ovaries of houseflies held on sucrose and water over a number of days. The female adults were obtained from the larvae reared on diets containing (4—^{14}C) cholesterol (0.56 μmole/g of diets).

	Female adults			*Ovaries*		
Days after eclosion	Wet weight (mg/insect)	Total sterol (nmole/insect	Protein (mg/insect	Wet weight (mg/ovaries)	Total sterol (μmole/ovaries	Protein (mg) ovaries
1	7.00±0.50	12.07±0.40	1 02±0.31	0.42±0.05	0.18±0.02	0.05±0.01
2	7.65±0.84	12.00±0.80	1.24±0.05	0.54±0.07	0.44±0.03	0.14±0.02
3	9.20±1.20	12.98±1.90	1.37±0.56	1.17±0.20	1.58±0.08	0.95±0.12
5	8.10±0.50	12.30±0.22	1.54±0.30	2.21±0.17	2.68±0.12	1.59±0.33
8	8.70±1.00	12.40±0.35	1.56±0.34	2.18±0.23	2.58±0.30	0.80±0.18
10	10.22±0.89	13.37±1.18	1.99±0.40	2.10±0.85	2.61±0.31	1.15±0.21

Results are given as mean ± S D of three determinations.

TABLE 6. The percentage of radioactivity associated with free sterol, sterol esters, and other areas after separation on thin-layer chromatographic plates of lipid extract of the female adults and isolated pairs of ovaries of hauseflies held on sugar and water for 10 days. The adults were obtained from the larvae reared on diets containing (4—^{14}C) cholesterol (0.56 μmole/g of diet).

Days after eclosion	Radioactivity at the point of application (%)	'Polar sterols (radioactivity between point of application and free sterols) (%)	Free sterols (%)	Sterol esters (%)
Female adults				
1	1.9±0.6	2.0±0.6	86.1±1.1	10.0±0.7
3	1.5±0.2	1.6±0.3	84.4±0.6	12.5±0.8
5	1.2±0.4	1.7±0.3	71.1±2.0	26.0±2.0
8	1.8±0.6	1.5±0.5	71.3±2.7	25.7±2.1
10	2.2±1.5	1.6±0.4	71.7±0.8	24.5±1.1
Ovaries				
1	2.4±0.8	3.0±0.8	90.1±1.2	4.5±0.9
3	1.2±0.8	2.4±0.6	52.8±0.5	43.6±1.1
5	2.0±0.5	2.8±0.8	48.5±1.15	46.7±1.7
8	2.3±0.3	2.7±0.5	48.7±1.1	46.3±2.0
10	2.3±0.2	3.0±0.5	48.1±1.0	46.7±1.6

Results are given as means ± S D of three determinations.

of female adult flies did not change significantly over number of days. However, the total sterol and protein content from the ovaries of houseflies increased on the third day after eclosion of the flies. A visual observation indicated that an appreciable increase in the size of ovaries took place on the third day after emergence of houseflies.

Sterol metabolites of female adults and their ovaries:

The percentage of radioactivity recovered as free sterols, sterol esters, and 'polar sterols' after chromatographic separation of lipid extract of female adults and ovaries of houseflies held on sucrose and water over a period of ten days is given in Table 6. It indicates that the percentage of free sterols is approximately 86—90% on the first day of development of newly emerged female adults and their ovaries. However the percentage of free sterol of the insect decreased on third day of development of the flies which appeared to be associated with the increase in cholesterol esters both in whole flies and ovaries. The increase in the percentage of sterol esters in the ovaries was higher than that observed in female adults; and apparently an equilibrium was reached between the proportion of free sterols and sterol esters of the ovaries on the third day of eclosion of the flies. The percentage of radioactivity recovered as 'polar sterols' appeared to be slightly higher in the ovaries than that present in the whole insects. The content of 7-dehydrocholesterol in female adults (relative to wet weight of the insect) and ovaries (relative to wet weight of tissue) is represented in Fig. 1. It shows that 7-dehydrocholesterol content in whole insect increased probably on the fourth or fifth day after eclosion of the fly. However, it increased apparently in a linear fashion in the ovaries over a period of ten days.

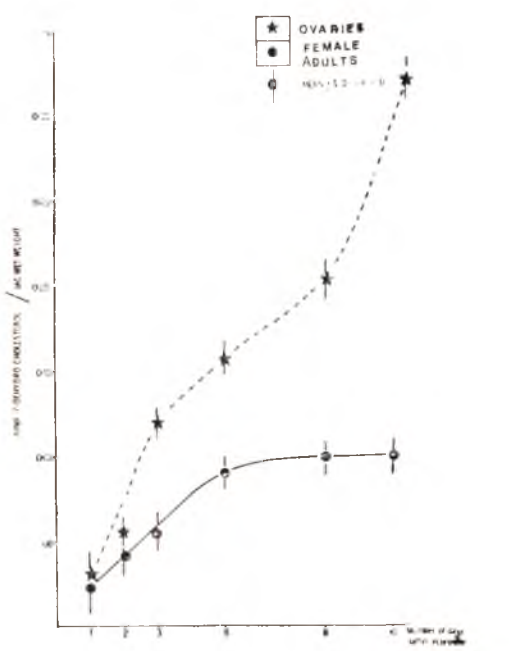

Fig. 1. The content of 7-dehydrocholesterol extracted from the lipid extract of female adults and ovaries of the control flies (0.56 μmole cholesterol/g diet) maintained on sugar and water after emergence for a period of ten days.

Effect of sterols and amino acids on ovarian maturation:

House flies were reared on larval diets containing two different concentrations (0.05 μmole/g diet; 0.56 μmole/g diet) of cholesterol. The adult females were segregated after emergence and were held on sugar and water for the rest of the period. Some of the adult females receiving higher cholesterol (0.56 μmole) were separated and fed for 48 hrs on a mixture of amino acids (w/w) used by HOUSE (1954) to which asparagine, glutamine, and B-alanine were added. The results are given in Fig. 2. It indicates that the ovaries did not develop in adults when

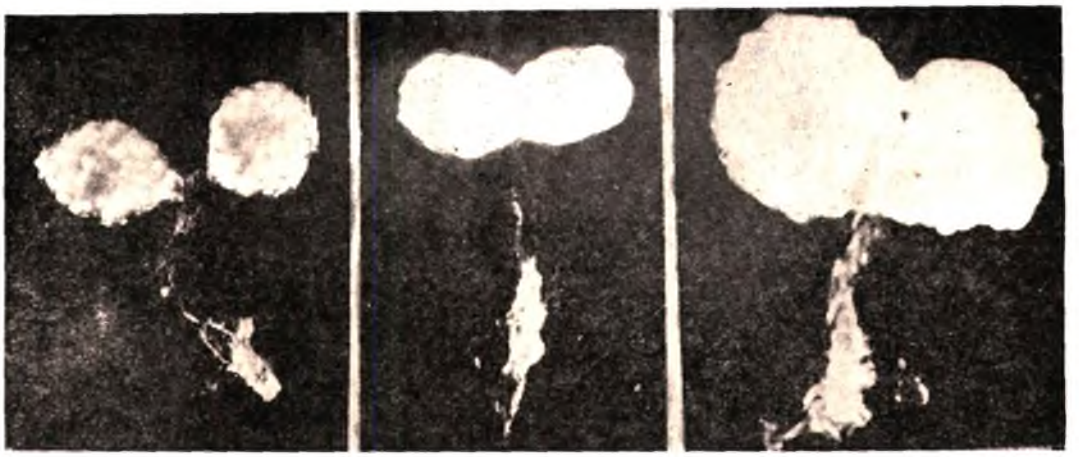

Fig. 2. Effect of larval dietary cholesterol on the ovarian maturation of flies. 2 (a), left, ovaries of cholesterol deficient 4 day old flies maintained on sugar and water. 2 (b), middle, ovaries ef 4 day old control flies (0.56 mole cholesterol/g diet) maintained on sugar and water. 2 (c), right, ovaries of 4 day old control flies (0.56 μmole cholesterol/g diet) maintained on sugar and water along with a mixture of amino acids for 48 hours.

their larval diets contained deficient cholesterol (Fig. 2A). The flies from larvae reared on the diets containing a higher concentration of cholesterol (0.56 μmole/g diet) developed ovaries, and these ovaries appeared to contain yolk in their oocyte during the period houseflies were maintained on sugar and water (Fig. 2B). However, amino acids added diet led to complete maturation of the ovaries (Fig. 2C).

DISCUSSION

The sterol content of the houseflies reared on 0.56 μmole cholesterol g of diet was found to be 0.013 ± 0.006 μmole/male adult, and 0.023 ± 0.009 μmole/female adult. These values were slightly less than reported earlier for the housefly (MONROE *et al.*, 1967). The phospholipid content of both sexes of adult flies were not affected significantly as a result of changes made in dietary cholesterol. However, slight decreases ($0.01 < P < 0.02$) were observed in those female adults which were reared on 3.35 μmole cholesterol/g diet and above (Table 2). The cholesterol to phospholipid ratios in both sexes of adult house-flies increased much more rapidly when the diet contained up to 0.56 μmole cholesterol/g of larval diets compared to the ratios observed from the insects reared on diets containing a higher concentration of cholesterol. Similar results were observed for the larvae of the housefly (DWIVEDY, 1975). The ratios were higher in the larvae than observed in adults. Female adults were having a slightly higher values ($P < 0.005$) than the male adults apparently due to a higher content of sterol present in them. A higher titre of sterols in the female than in the male insects had already been reported for *Hyalophora cecropia* (GILBERT & GOODFELLOW, 1965) and *Periplaneta americana* (LASSER *et al.*, 1966).

The percentage of cholesterol esters found in the housefly larvae were very small and approximately 97% of the radioactivity of the larvae was recovered as 'free sterol', irrespective of increase in the dietary cholesterol (DWIVEDY, 1975). A minimum quantity of essential cholesterol was found necessary for the development of cockroach, *Eurycotis floridana*, and was found utilized in unesterified form when insects were reared on deficient cholesterol diets (CLAYTON & EDWARDS, 1961; LASSER *et al.*, 1966). The present results suggest that deficiency of the larval dietary cholesterol caused a low level of sterol esters (found to be less than 3%) in both sexes of adult flies. The ovaries of the flies on deficient cholesterol failed to develop when the flies were maintained for a number of days on sugar and water Fig. 2a). Increasing the concentration of dietary cholesterol to 0.28 μmole/g of larval diet or above resulted into a rapid increase of sterol esters in the adults, much higher in female adults (approximately 24%) than in male adults (approximately (10%). The ovaries of the adult flies reared on a higher concentration of dietary cholesterol (0.56 μmole/g diet) indicated that sugars supplied to the adults led to the beginning of yolk deposition in the ovaries on the third day after eclosion of the fly (Fig. 2b). Although the content of sterol and protein of the ovaries were found to be increased on the third day after emergence of the fly (Table 5), full maturation of the ovaries was observed only when a mixture of amino acids were added to the diets (Fig. 2c).

The ovarian maturation in the housefly had been characterised by various phases (GOODMAN *et al.*, 1968; SAKURAI, 1973; TREPTE, 1979). Biochemical investigations further indicated that the completion of the first gonadotrophic cycle reached on the third day after emergence of the flies (HALL *et al.*, 1976).

The cholesterol ester may be stored in the yolk of insect's eggs as reported for the housefly (MONROE *et al.*, 1967) and silkmoth (ICHIMASA, 1976). Further evidence from the housefly suggested that the fraction of sterol esterified in the eggs decreased on each period of successive collections of eggs (MONROE *et al*, 1968). Present studies also indicated a significant increase of the sterol esters and finally reaching to an equilibrium with the free sterols of the ovaries of the houseflies on the third day after eclosion of adults. This finding suggests that cholesterol esters accumulate mainly in the yolk of the ovaries apparently on the third day of the eclosion of the housefly.

Although presence of 7-dehydrocholesterol in the eggs of housefly was repported previously (MONROE *et al.*, 1967, 1968), it was surprising to observe a continuous increase in the accumulation 7-dehydrocholesterol in the ovaries of the housefly maintained on sugar and water. The present results do not indicate where the 7-dehydrocholesterol is synthesized. However, evidence on *Locusta migratoria* suggests that cholesterol can be utilised by the ovaries for the synthesis of ecdysone (LAGUEUX *et al.*, 1977) which is required for ovarian competence (BELL & SAMS, 1975) and vitellogenin synthesis (BOHM *et al.*, 1978). The ovaries of various insects have been shown to be sources of ecdysone or compounds with an ecdysone type of structures (LAVERDURE, 1971; HAGEDORN *et al.*, 1975; LEGAY *et al.*, 1976) which appear to be concentrated in the oocyte and eggs of the insects (LAGUEUX *et al.*, 1977; GANDE & MORGAN, 1979). It can be considered, therefore, that 7-dehydrocholesterol would be an intermediate in the bio-synthesis of ecdysteroids

by the ovaries of the housefly when they are maintained on sugar and water over a period of time. The formation of ecdysteroids, and whether the inhibition of ovarian development is a reflection of their absence as it is observed in cholesterol deficient females is a subject for further investigation.

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PHYSIOLOGICAL ACTIVITY OF THE NEUROACTIVE SUBSTANCE RELEASED INTO COCKROACH BLOOD BY THE ACTION OF HEPTACHLOR

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(Received 15 January 1982)

Neuroactive substance was isolated from the blood of *Periplaneta americana* L. poisoned by heptachlor. While studying on the isolated cockroach heart, using certain drugs, a contrast in the action of insecticide and its neuroactive substance was observed. Unlike insecticide, the neuroactive principle was found to have nicotinic action on the heart with some difference in the mode of activity.

(Key words: neuroactive substance, physiological activity, release, blood, heptachlor, cockroach, nicotinic action, mode of activity)

INTRODUCTION

Earlier studies indicate that insecticides by their action on the nervous system of the insects, will release certain toxic substances which are supposed to be lethal to the insects. Inects subjected to excessive stress were found to release pharmacologically active agents from their central nervous system and large amounts of these agents cause auto-intoxication that often results in paralysis and death of the insects. Presence of neuroactive substance in the blood of cockroaches and crayfish poisoned with DDT has been reported by STERNBURG *et al.* (1959); HAWKINS & STERNBURG (1964). They have isolated the toxic principle by paper chromatography and recorded high activity on the isolated nerve cord of cockroach and cray fish. They are believed to be chemically and biologically active compounds. Blood from cockroaches treated with TEPP, possessing high spontaneous activity on the isolated nerve cord and an increase in the frequency of heart beat has been studied by STERNBURG (1960) and COLHOUN (1958). Release of certain neurosecretions into the blood of cockroach by the activity of pyrethrum and malathion was reported by SUDERSHAN & NAIDU (1967). In the present studies an attempt has been made to isolate the neuroactive substance from heptachlor treated cockroach blood and its biological activity was studied on the isolated cockroach heart. Certain drugs such as nicotine, eserine and atropine were employed so as to understand the site and mode of action of the neuroactive substance.

MATERIALS AND METHODS

Cockroaches, *Periplaneta americana* L. were reared in the laboratory by feeding on biscuits mixed with yeast powder and potato peels. In all the experiments only adult insects were used. To prepare the test solutions, heptachlor and neuroactive substance were dissolved in ethanol to the required concentration, while nicotine, atropine and eserine were dissolved in distilled water. Heptachlor was treated intraperitoneally to cockroaches as described by MENUSAN (1948). Treated insects were transferred to observation

cages for a minimum period of three hours before collecting the blood by refrigerated centrifuge at 2000 rpm. For extraction, isolation and purification of the neuroactive substance from cockroach blood, the technique developed by STERNBURG *et al.* (1959) was followed. Isolated cockroach heart technique described by KRIJGSMAN *et al.* (1950) and improved by NAIDU (1955) was adopted to study the physiological effects.

RESULTS AND DISCUSSION

Heptachlor 1.3×10^{-6} M; 2.6×10^{-6} M and 5.3×10^{-6} M conc., produced a sudden increase in the heart beat frequency followed by a decline. The neuroactive substance 1.6×10^{-6} and 3.3×10^{-6} conc., when administered to the isolated heart also caused high stimulation followed by gradual decline, thereby showing its biological activity on the cockroach heart (Fig. 1).

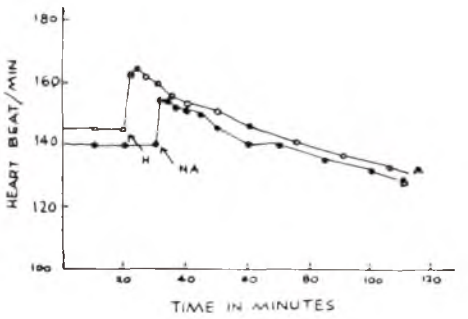

Fig. 1. Effect of heptachlor H and its neuroactive material N on isolated heart of cockroach as observed at different concentrations.

After prolonged action of nicotine, heptachlor did not show any action on the heart. When the treatment was reversed the action of nicotine was evident (Fig. 2). It is suggested that heptachlor does not produce its action by causing paralysis of the ganglia as nicotine does, but by stimulating the ganglia. While after prolonged treatment with nicotine, euroactive substance did not show any action on the heart beat frequency. When the treatment was reversed nicotine action was significantly reduced, suggesting thereby a common site of action for nicotine and the neuroactive substance (Fig. 2). Further, similar to nicotine the neuroactive substance also appears to paralyse the cardiac ganglia.

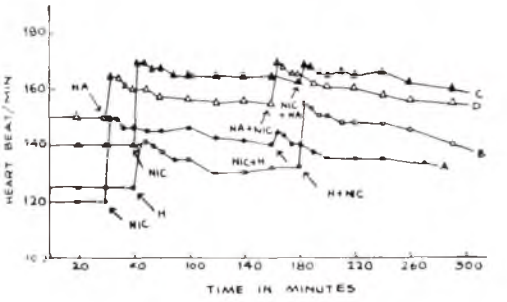

Fig. 2. Effect of nicotine N after prolonged action 3 hr of heptachlor H and neuroactive substance NA and *vice versa*.

Atropine, a cholinergic blocker when added to the heart preparation, previously treated with heptachlor, does not interfere with the action of the insecticides. Eserine an anticholinesterase did not potentiate the action of heptachlor. These findings prove that acetylcholine is not involved in the action of heptachlor. Similar observations were made using neuroactive substance in place of heptachlor (Fig. 3). It is well known that acetylcholine is

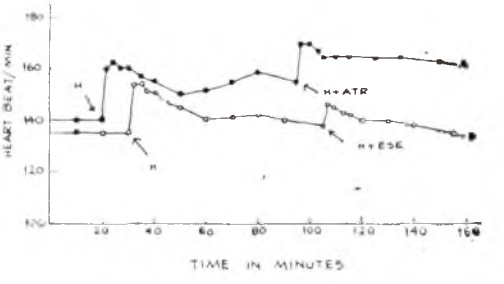

Fig. 3. Effect of atropine ATR and eserine ESE after the treatment of neuroactive substance NA or heptachlor H.

involved in the action of nicotine and nicotine very strongly mimics the Ach. Therefore, a difference in the mode of action of the neuroactive substance and nicotine is quite possible although both act on the central nervous system.

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Entomon, 1982, *Vol.* 7, *No.* 4, *pp.* 427 *to* 429

TWO NEW SPECIES OF *BREVIPALPUS* (TENUIPALPIDAE: ACARINA) FROM TAMILNADU

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(*Received* 7 *October 1982*)

The paper presents the description of two new species of tenuipalpid mites, viz. *Brevipalpus cucurbitae* sp. nov. and *Brevipalpus euphorbiae* sp. nov. collected from Tamilnadu.

(*Key words*: new *Brevipalpus*, Tenuipalpidae from Tamilnadu)

1. Brevipalpus cucurbitae sp. nov. (Figs. 1 to 3)

Female:

Red in colour, 265[1] long including gnathosoma; gnathosoma 45 long; body 158 wide at its broadest point. Rostrum reaching more than half the length of femur I with a pair of short setae on the ventral side; palpus four segmented, segment I, 4 long, II, 12 long with a long seta towards its anterior half; III, 6 long with a long seta at about middle, IV, 3 long with two spines and a sensory peg at its tip. Rostral shield bifurcate, shield tip blunt, reaching the base of femur I; propodosoma with polygonal reticulation; three pairs of dorsal propodosomals, DP I, 7 long; DP II, 6 long; DP III, 10 long. Hysterosoma with a reticulate pattern in the middle and broader cells in the sides; 3 pairs of dorsocentrals, DH I, 8 long; DH II, 5 long; DH III, 4 long; one pair of humerals, 4 long; six pairs of dorsolaterals DLH I, 7 long; DLH II, 4 long, DLH III, 6 long; DLH IV, 6 long, DLH V, 6 long, DLH VI 7 long; all setae on dorsum lanceolate and serrate. Venter—The podosoma bears a pair of short anterior and a pair of long posterior medioventral setae; one pair of medioventral setae on ventral plate; two pairs of genital and two pairs of anal setae; all setae on venter simple except genital setae which are lanceolate and serrate.

Setae on legs I to IV: Coxae, 3, 2, 1, 1; trochanter, 1, 1, 1, 1; femora, 4, 4, 2, 1; genua, 3, 3, 1, 1; tibiae, 5, 4, 3, 2; tarsi, 6 (1), 8 (1), 4, 4.

Male: Not known

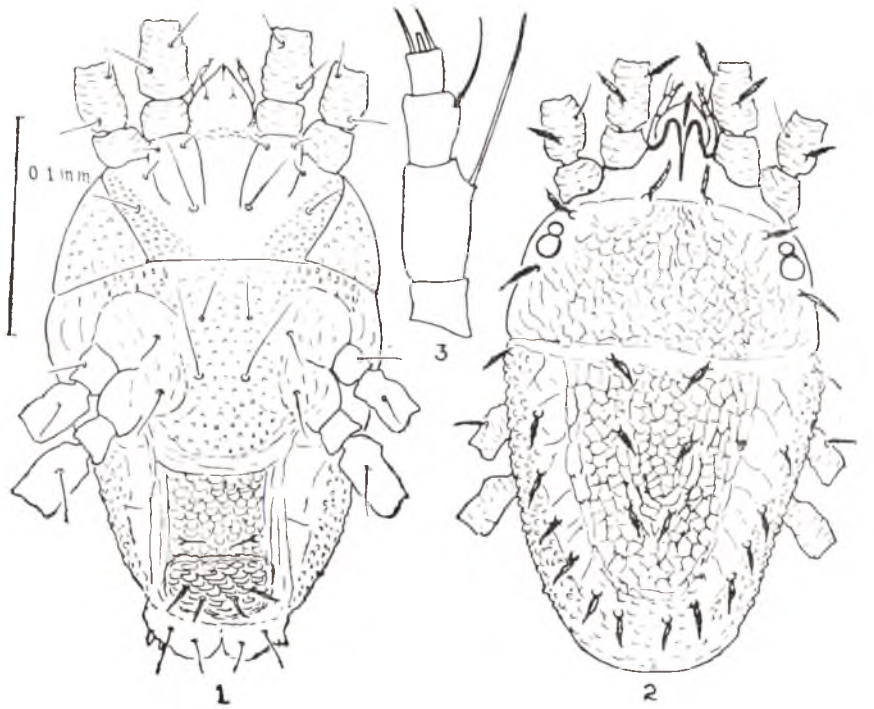
Types: A **holotype** slide and 9 **paratype** slides all with females, INDIA Coimbatore, on *Cucurbita maxima* (Cucurbitaceae), 14.v 1979, coll. Mohanasundaram (No. 1) (TNAU)

Remarks: This species resembles *Brevipalpus phoenicis* (Geijskes) (Sayed, 1946) but could be differentiated from it by the reticulate pattern on the dorsum, the shape of the rostral shield and the size of the dorsal setae.

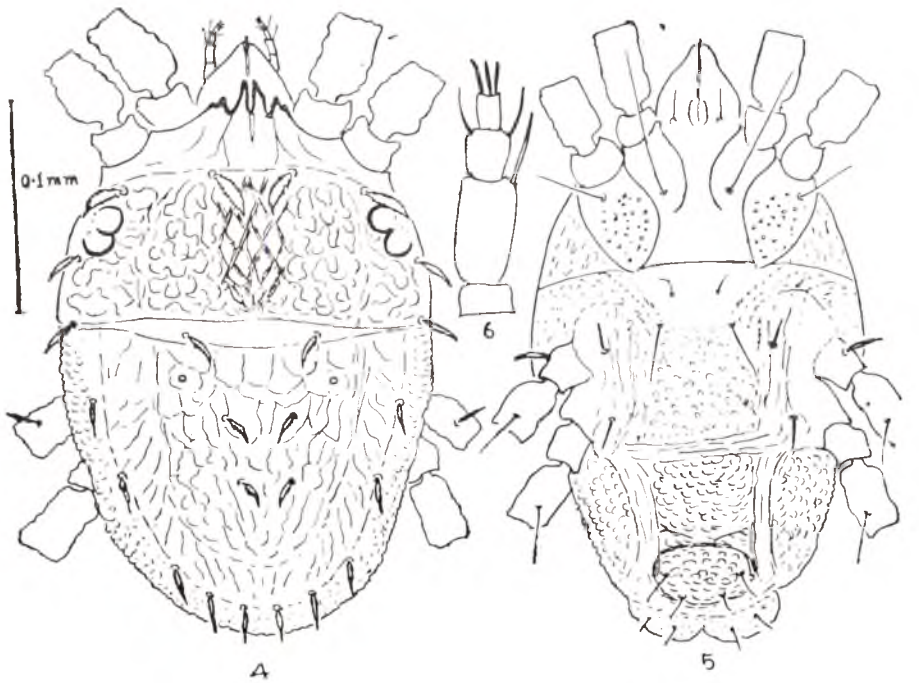
2. Brevipalpus euphorbiae sp. nov. (Figs. 4 to 6)

Female: Red in colour, 280 long including rostrum, 180 wide; gnathosoma with a pair of simple spines on the ventral side; rostrum extending beyond the middle of femur I; palpus 4 segmented, segment

[1]Measurements are in μm, unless otherwise stated.



Figs. 1—3. *Brevipalpus cucurbitae* sp. nov. 1. Ventrel view; 2. Dorsal view; 3. Palpus.



Figs. 4—6. *Brevipalpus euphorbiae* sp. nov. 4. Dorsal view; 5. Ventral view; 6. Palpus.

I, 4 long; segment II, 17 long with a seta at its anterior end; segment III, 7 long with two setae at its anterior end, segment IV, 4 long with 3 spines at its tip. Rostral shield bifurcate with further clefts on either side, and reaching upto the base of femur I; propodosoma with a reticulate pattern in the middle with broader reticulations on the sides; three pairs of dorsal setae, each 10 long, broadly lanceolate and serrate. Hysterosoma with a reticulate pattern in the middle and broad cells on the sides; a pair of humerals 8 long; 5 pairs of dorsolaterals, DLH I, 7 long; DLH II, 9 long; DLH III, 10 long; DLH IV, 8 long; DLH V, 6 long; three pairs of dorsocentrals DCH I, 6 long; DCH II, 5 long; DCH III, 5 long; all setae on dorsum lanceolate and serrate.

Venter with a pair of medioventral propodosomals, 40 long, metapodosoma with a pair of short anterior medioventral metapodosomals and a pair of long posterior medioventral metapodosomals; the area around the hind coxal base reticulate; one pair of medioventral setae on ventral plate; two pairs of genital and two pairs of anal setae; all setae on venter simple except the genital setae which are lanceolate and serrate.

Setae on legs I to IV: Coxae, 1, 1, 1, 1; trochanter, 1, 1, 1, 0; femora, 4, 4, 2, 1; genua, 4, 3, 1, 1; tibiae, 4, 4, 3, 3; tarsi, 6 (1), 6, 4, 4.

Male: Not known.

Types: A **holotype** slide and 8 **paratype** slides, all with females, INDIA, Coimbatore, on *Croton* sp. (Euphorbiaceae) 10.v.1979, Coll. Mohanasundaram, (No. 2) (TNAU)

Remarks: This species resembles *Brevipalpus californicus* (Banks) (Mc Gregor, 1949) in its general appearance, but could be differentiated from it by the dorsal pattern, shape of the rostral shield and the structure of the palpus.

The type and paratype slides have been deposited in the Department of Agricultural Entomology collections, Tamilnadu Agricultural University, Coimbatore, India.

Acknowledgement: The author wishes to thank Dr. E. W. Baker, USDA, California for the supply of xerox copies of his works on tenuipalpidae and for the encourapement given for the study of this group of mites.

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TWO NEW SPECIES OF ERIOPHYIDS (ERIOPHYIDAE: ACARINA) FROM INDIA

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(Received 7 October 1981)

The paper presents the descriptions of two new species of Eriophyide mites, viz, *Eriophyes delhiensis* sp. nov. and *Aculops kumari* sp. nov. collected from Delhi.
(Key words: new eriophyids from Delhi)

1. Eriophyes delhiensis sp. nov. (Figs. 1 to 9)

Female: Worm like, 175—180[1] long, 40 thick, rostrum 18 long, uniformly down curved; antapical seta 5 long. Shield 30 wide, 28 long; median complete, admedians complete, submedian represented in the rear three fourths; rest of the area and sides of shield clear; dorsal tubercles 15 apart, at the rear shield margin; dorsal setae 30 long, pointing backwards; foreleg 25 long; tibia 5 long; tarsus 6 long; claw 7 long, slightly curved; feather claw 6 rayed; hind leg 23 long, tibia 4 long; tarsus 5 long; claw 7 long; coxae with all three setiferous tubercles; seta I, thin at anterior margin of forecoxae; seta II and III long and prominant; coxal area smooth. Abdomen with about 70 uniformly microtuberculate rings; lateral seta 20 long on ring 10; first ventral seta 55 long on ring 22; second ventral seta 8 long on ring 45; third ventral seta 22 long on ring 6 from behind; caudal seta 95 long; accessory seta 10 long, very thin; female genitalia 18 wide, 10 long, coverflap with about 14—16 lines, genital seta 40 long.

Male: 160—170 long, 40 thick, genitalia 15 wide; genital seta 35 long.

Types: A **holotype** slide with 3 ♀♀ and 4 **paratype** slides with 3 ♂♂ and 3 ♀♀ collected on 2.v.1981 at road side near Buddha Jayanthi Gardens, NEW DELHI, INDIA, ex unidentified spiny shrub, coll. Mohanasundaram (No. 410) (TNAU)

Remarks: The mites are found in the vegetative and floral buds and tender shoot.

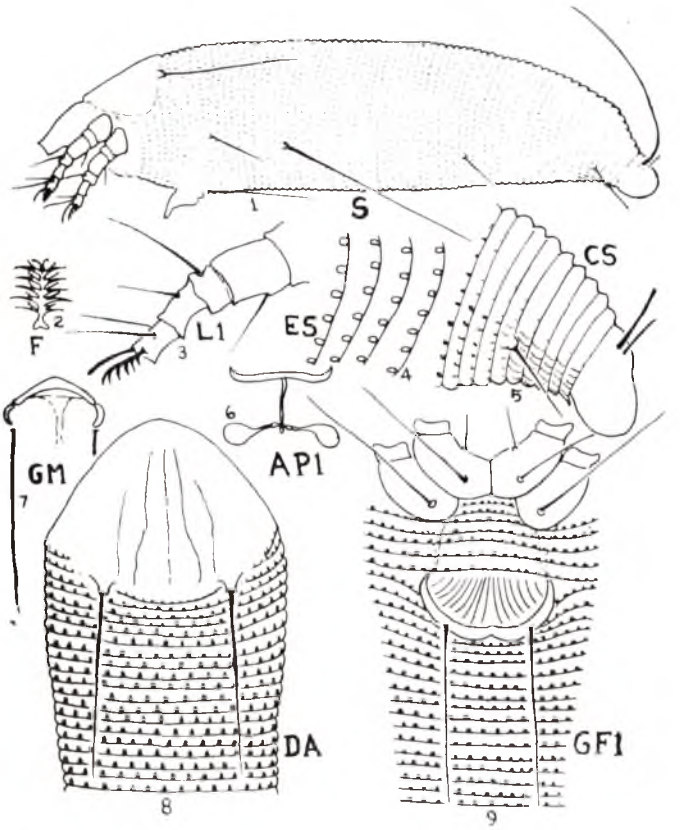
Discussion: This species resembles *Eriophyes cajani* (Channabasavanna) (1966) in its shield lines, but could be differentiated from it by the smooth sides of the shield, the larger number of scorings on the female genital coverflap; the longer genital seta, apart from other measurements.

2. Aculops kumari sp. nov. (Figs. 10 to 17)

Female: Worm like, 165—170 long, 40 thick; rostrum 15 long, evenly down curved; antapical seta 3 long; shield 30 wide, 20 long without any lines; dorsal tubercles at rear shield margin 13 apart; dorsal seta 27 long, pointing backwards and outwards. Foreleg 22 long; tibia 4 long; tibial seta 2 long; tarsus 5 long;

Types are deposited in the Department of Agricultural Entomology Collections, Tamilnadu Agricultural University, Coimbatore, India.

[1]Measurements are in μm, unless otherwise stated.

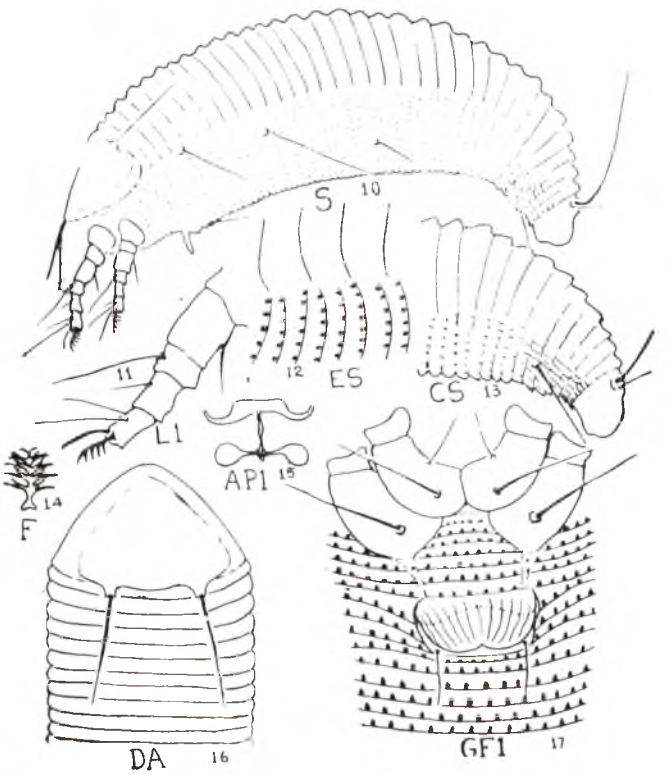


Eriophyes delhiensis sp. nov. Fig. 1. Side view of mite; 2. Feather claw; 3. Left foreleg; 4. Side skin structure; 5. Side view of caudal end; 6. Internal female genital apodeme; 7. Genitalia of male; 8. Dorsal view of anterior end; 9. Female genitalia and coxae from below;

claw 6 long, straight; feather claw 5 rayed. Hind leg 20 long, tibia 3 long, tarsus 4 long; claw 9 long. Coxae with all three setiferous tubercles; coxal area clear. Abdomen with about 40 tergites and 55 sternites. Tergites smooth; sternites uniformly microtuberculate along the hind margin of each ring. Lateral seta 15 long on ring 10; first ventral seta 40 long on ring 20; second ventral seta 7 long on ring 33; third ventral seta 12 long on ring 6 from behind. Female genitalia 17 wide, 10 long; cover flap with 10—12 thin lines; genital seta 7 long.

Male: 140—150 long; 35—40 thick, genitalia 15 wide; genital seta 6 long.

Types: A **holotype** slide with 3♀♀ and seven **paratype** slides with 3 ♂♂ and 3 ♀♀, collected on 2.v.1981 at Buddha Jayanthi Gardens, New Delhi, ex unidentified tree, Coll. Mohanasundaram (No. 409) (TNAU). **Remarks:** The mites form bud and leaf galls, making the shoot and leaves distorted. This species is named after Mr. S. Kumar, Entomologist, Indian Agricultural Research Institute, New Delhi who helped to collect this species.



Aculops kumari sp. nov. Fig. 10. Side view of mite; 11. Left foreleg; 12. Side skin structure; 13. Side view of caudal end; 14. Featherclaw; 15. Internal female genital apodeme; 16. Dorsal view of anterior end; 17. Female genitalia and coxae from below.

Discussion: This species resembles *Aculops knorri* Keifer (1976) in its shield pattern but differentiated from it by the five rayed feather claw, more number of scorings on the female genital cover flap; thinner and longer legs, and position of the first setiferous coxal tubercles.

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Entomon, 1982, *Vol.* 7, *No.* 4, *pp.* 435 *to* 440

A NEW GENUS AND THREE NEW SPECIES OF ERIOPHYID MITES (ACARINA : ERIOPHYOIDEA) FROM WEST BENGAL, INDIA

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(Received 7 October 1981)

A new genus, *viz.*, *Indonotolox* under the subfamily Phyllocoptinae and three new species of eriophyid mites., *viz. Colopodacus combretus, Indonotolox sudarsani* and *Neorhynacus combretis* infesting *Combretum decundrum* Roxb. (Combretaceae) are described from the Bankura district, West Bengal.

(Key word: Acarina, eriophyids, taxonomy, morphology, new genus, new species, India)

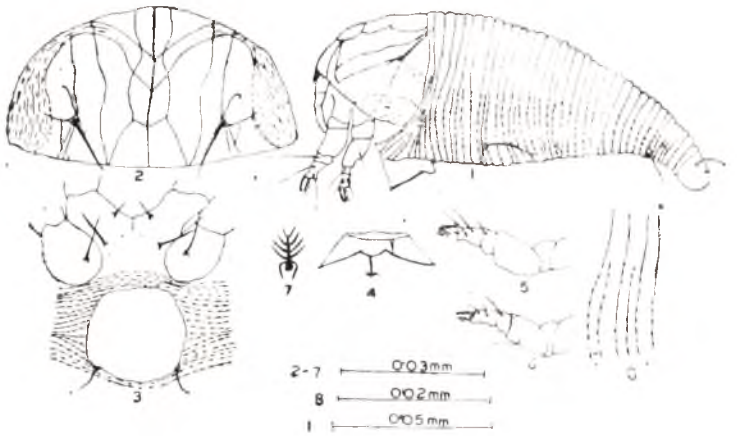
1. Colopodacus combretus sp. nov. (Figs. 1—8).

Female: Body 120-141[1] long, 57-65 wide, fusiform elongated, brownish yellow in colour. Rostrum short 15-20 long, projecting downward; subapical setae 3-5 long. Shield semicircular, without distinct anterior lobe; median line complete; admedian lines sinuate, arising from the anterior margin of shield, runs posteriorly first convergently upto 0.33 part then divergently and again convergently upto 0.66 part and meets the rear shield margin divergently; admedian lines meet the median line by three oblique lines on the middle of shield; submedian lines two; first submedian line arising from anterior lateral shield margin runs backwardly and ultimately meets the rear end of admedian lines on either side; second submedian runs nearly parallel to first submedian touching the base of dorsal tubercles on 0.33 part posteriorly; lateral shield with several irregular longitudinal lines. Dorsal tubercles placed 12-14 ahead of rear shield margin and 29-37 apart from each other; dorsal setae 14-18 long directed caudad convergently. Foreleg 26-29 long from the trochanter base; femur 8-11 long; patella 4-5 long with setae 23-27 long; tibia and tarsus fused and 7-9 long with setae 18-23 long, claw blunt, 6 long; featherclaw simple and 4-rayed. Hind leg 23-26 long from the trochanter base; femur 7-10 long with setae 12-15 long; patella 4-5 long with setae 18-21 long, tibia and tarsus fused and 6-8 long with setae 18-22 long; other characters as in foreleg. First coxa broadly contiguous and smooth; first coxal setae situated just on the line of anterior coxal approximation; second setiferous coxal tubercles, divergent, situated below the line of first coxal tubercles and well ahead of the transverse line between the third coxal tubercles.

Abdomen with about 35-37 tergites and 45-48 sternites; lateral setae on sternite

[1] All measurements are expressed in μm unless otherwise stated.

All the type materials are deposited in the Biasystematics Research Unit, Department of Zoology, University of Kalyani.



Colopodacus combretus sp. nov. (Figs. 1–8) Female: 1—lateral view of mite; 2—anterior dorsum of mite; 3—coxae and female genitalia; 4—internal female genitalia (apodeme); 5—foreleg; 6—hindleg; 7—featherclaw; 8—side view of skin structure.

8 and 12-17 long; first ventral setae on sternite 19 and 27-38 long; second ventral setae on sternite 29 and 6-8 long: third ventral setae on sternite 41 and 14-17 long; caudal setae 38-42 long; accessory setae 3 long; bead like microtubercles present on the sternite. Genitalia 16-20 long, 20-23 wide, genital setae 6-8 long, coverflap smooth.

Male: Unknown.

Holotype: ♀, (on slide No. 251/102/80), INDIA: WEST BENGAL: Bankura; Dubrakone, 30.vii.1981 from *Combretum decundrum* Roxb. (Combretaceae), coll. B. Ghosh.

Paratypes: Many ♀♀, on the holotypic slide and on 2 slides (Nos. 252/102/80 and 253/102/80), collection data as in holotype; many ♀♀, on 1 slide (No. 254/102/80), collected from Bankura; Dubrakone, 1.i.1980; many ♀♀, on 2 slides (Nos. 255/102/80 and 256/102/80) collected from Bankura; Dubrakone, 6.v.1980 from *Combretum decundrum* Roxb. (Combretaceae), coll. B. Ghosh.

Distribution: INDIA: West Bengal.

Remarks: The genus *Colopodacus* Keifer (1960) is known by only 3 species, viz., *C. apricanus* Keifer (1960), *C. glochidionis* Keifer (1969) and *C. cinnamomae* Mohanasundaram (1980). The present new species is very close to *C. glochidionis* Keifer and *C. cinnamomae* Mohanasundaram in having 4-rayed featherclaw and nonmicrotuberculated tergites, but differs from the above species by details of armature of shield, direction of dorsal setae, number of tergites and sternites and coxal ornamentation.

Indonotolox gen. nov.

Rostrum moderate and projecting down; anterior shield lobe prominent; dorsal tubercle set ahead of rear shield margin and setae pointing up and divergent; rear end of shield modified into a horny projection with a guide; first coxal and fore tibial setae absent; featherclaw simple, tergites broader than sternites, forming a broad longitudinal dorsal trough and a lateral ridge, all abdominal setae

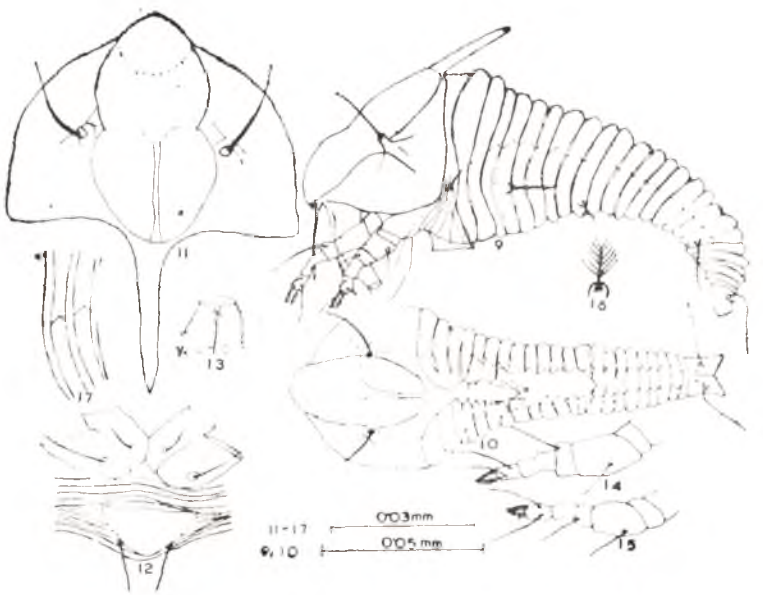
present, female genital coverflap smooth.

Type species: *Indonotolox sudarsani* sp. nov.

Remarks: Among the genera under the subfamily Phyllocoptinae having dorsal tubercles set ahead of rear shield margin and the setae directing ahead or up, this genus shows its affinity towards *Notolox* Keifer (1961) by trapezoidal species, widest across rear end of shield and longitudinal trough on thanosome. But the present genus differs from the former genus in having the horny projection on the rear shield end: broad longitudinal trough on thanosome and absence of first coxal and fore tibial setae.

2. Indonotolox sudarsani sp. nov. (Figs. 9—17),

Female: Body 123-136 long, 48-54 wide, spindle shaped body, yellowish brown in colour. Rostrum 23-28 long downwardly projected, subapical setae 7-9 long. Shield 67-69 long including projection, 48-50 wide, more or less triangular in shape with prominent anterior shield lobe over the rostral base and a horny projection from the rear shield end; median line present on the posterior half of shield admedian complete and a woolly transverse line meets with the median line; prominent dorsal tubercles and the dorsal setae projecting up and divergently and 15-17 long, 27-29 apart from each other and 18-23 ahead of rear margin of shield. Forelegs 27-31 long from the trochanter base; femur 7-9 long with seta 15-20 long; pattella 3-5 long with seta 20-23 long; tibia 6-8 long without setae; tarsus 4-6 long with 2 setae 21-24 long; claw knobbed and 6-8 long; featherclaw simple and 6-rayed. Hind leg 21-24 long from



Indonotolox sudarsani gen. *et.* sp. nov. (Figs. 9—17) Female: 9—lateral view of mite; 10—dorsal view of mite; 11—anterior dorsum of mite; 12—coxae and female genitalia; 13—internal female genitalia (apodeme); 14—foreleg; 15—hindleg; 16—featherclaw; 17—side view of skin structure.

the trochanter base; femur 6-8 long with seta 9-12 long; patella 4-5 long with seta 9-11 long; other characters as in fore leg. First coxa narrowly contiguous, first coxal setae and tubercle absent; second setiferous tubercles divergent, well ahead of the transverse line of the third.

Abdomen with equal number of tergites and sternites (27-31) ; lateral setae on sternite 4 and 11-14 long; first ventra setae on sternite 9 and 33-36 long; second ventral setae on sternite 13 and 6-8 long; third ventral setae on sternite 24 and 9-14 long; caudal setae 30-38 long and accessory setae 4-5 long. Genitalia 12-14 long, 18-22 wide; genital setae 9-11 long and coverflap smooth.

Male: Unknown.

Holotype: ♀ (On slide No. 257/102/80). INDIA: West Bengal: Bankura; Chhotakurpa, 1. iii. 1981 from *Combretum decundrum* Roxb. (Combretaceae), coll. B. Ghosh.

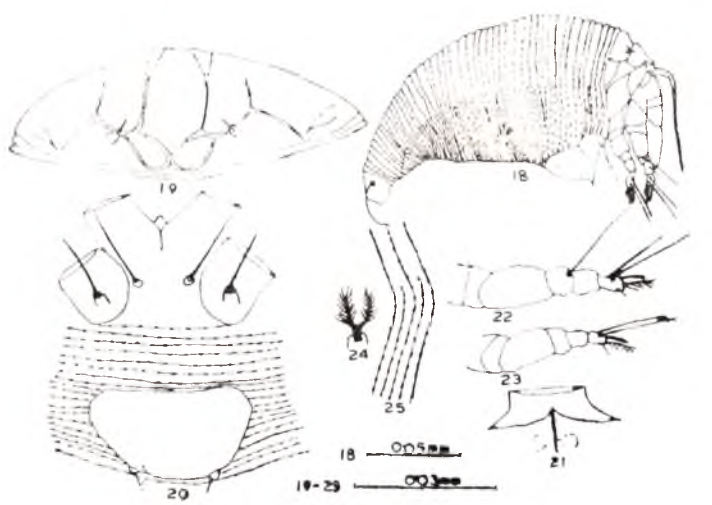
Paratypes: Many ♀♀, on the holotypic slide and on 2 slides (Nos. 258/102/80 and 259/102/80) collection data as in holotype; many ♀♀, on 1 slide (No, 260/102/80) collected from Bankura: Dubrakone, 1. i. 1980, coll. B. Ghosh; many ♀♀, on 2 slides (Nos. 261/102/80 and 262/102/80) collected from Bankura; Dubrakone. 6. v. 1980 from *Combretum decundrum* Roxb. (Combretaceae), coll. B. Ghosh

Distribution: INDIA: West Bengal.

The species is named after Late Prof. Sudarsan Singh, Principal, Bankura Christian College for encouraging our eriophyid studies.

3. Neorhynacus combretis sp. nov. (Figs. 18-25)

Female: Body 133-172 long, 70-85 wide, yellow in colour. Rostrum 20-24 long; subapical setae 4-6 long; cheliserata long and abruptly curved down. Shield subtriangular 23-29 long and 60-65 wide; anterior shield lobe absent; median line



Neorhynacus combretis sp. nov. (Figs. 18—25) Female: 18—laterol view of mite; 19—anterior dorsum of mite; 20—coxae and female genitalia; 22—internal female genitalia (apodeme); 22—foreleg; 23—hindleg; 24—featherclaw; 25—side view of skin structure.

absent: admedian present upto 0.75 of shield and bifurcated posteriorly to form two cell structures just above the rear margin; first submedian arises from the anterior shield margin and runs straight upto 0.5 of shield posteriorly where it bifurcates, one of these branches meets the admedian and the other meets with rear end of the shield obliquely; dorsal tubercle present but very short, 4-5 long dorsal setae, 15-18 apart and 8-12 ahead of the rear margin of shield. Foreleg 28-33 long from the trochanter base; femur 9-12 long; patella 4-6 long with seta 30-38 long; tibia 4-6 long with a very small seta (?); tarsus 6-8 long with two upper tarsal setae, one is longer 30-42 and other 23-27 long and a lower tarsal seta 6-9 long; featherclaw bifurcated and 7-rayed. Hindleg 23-26 long from the trochanter base; femur 7-9 long; patella 4-6 long; tibia 4-6 long; tarsus 6-8 long with setae 24-28 long. Anterior coxae broadly contiguous, first coxal setae absent; second setiferous coxal tubercle divergent, well ahead of the transverse line between the third coxal tubercles.

Abdomen with about 45-48 tergites and 72-75 sternites; microtubercles ditinctly present on sternites lateral setae absent but tubercles present; first ventral setae on sternite 24 and 5-8 long; second ventral setae on sternite 43 and 4-5 long; third ventral setae on sternite 61 and 15-18 long; caudal setae 45-54 long; accessory setae may be present. Genitalia 12-18 long, 21-27 wide; genital setae 6 long and coverflap smooth.

Male: Unknown.

Holotype: ♀ (On slide No. 263/102/80. INDIA: WEST BENGAL: Bankura; Dubrakone, 1.i.1980 from *Combretum decundrum* Roxb. (Combretaceae), coll. B. Ghosh.

Paratypes: Many ♀♀, on the holotypic slide and on 3 slides (Nos. 264/102/80 to 266/102/80), collection data as in the holotype and many ♀♀, on 2 slides (Nos. 267/102/80 and 268/102/80) collected from Bankura; Dubrakone, 6.v.1960 from *Combretum decundrum* Roxb. (Combretaceae), coll. B. Ghosh.

Distribution: INDIA: West Bengal.

Remarks: Among the Rhyncaphytoptid species, the present species is very peculiar in having combination of characters like absence of first coxal tubercles and setae, femoral setae, lateral setae and the presence of dorsal tubercles with setae set ahead of rear shield margin. If we consider the presence of dorsal tubercles and setae it seems to be one of the members of the genera other than *Diptilomiopus* Nalepa (1971) and *Rhynacus* Keifer (1951). However, other characters such as the absence of first coxal tubercles and setae, femoral seta and lateral ventral setae, brings the present species rather more nearer to a member of the genus either *Rhynacus* or *Diptilomiopus*.

Mohanasundaram (1981) erected *Neorhynacus*, which more or less fulfils all the characters except the first coxal tubercles and setae. At present this species is placed under *Neorhynacus* without erecting a seperate genus for it.

So, the genus *Neorhynacus* can be conceived with or without first coxal tubercles and hairs to accomodate the present species.

Acknowledgements: Thanks are due to the University Grants Commission, for financing the work through a grant-in-aid; to the Head, Department of Zoology, University of Kalyani, for laboratory facilities and to Mr. S. Monda of this laboratory for his active assistance in this work.

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Entomon, 1982, *Vol.* 7, *No.* 4, *pp.* 441 *to* 446

KARYOTYPE VARIATION OF *RHOPALOSIPHUM MAIDIS* (FITCH) (HOMOPTERA : APHIDIDAE)

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Variation in the number (2n = 8) and structure of mitotic chromosomes of *Rhopalosiphum maidis* (Fitch) has been studied. Samples were recorded from different host plants at different seasons. The probable reason for such variation is discussed.

(Key words: Aphid, cytotaxonomy)

INTRODUCTION

The corn leaf aphid *Rhopalosiphum maidis* (Fitch) is of immense economic importance because it causes considerable damage to various economically important plants (BODENHEIMER & SWIRSKI, 1957; GHOSH, 1975). The genus *Rhopalosiphum* has been receiving cytotaxonomical attention for sometime (SUN & ROBINSON, 1966; ROBINSON & CHEN, 1969; KUZNETSOVA & SHAPOSHNIKOV, 1973; GUT, 1976) So far as the authors are aware in India the karyological studies of *R. maidis* (Fitch) have been carried out earlier by KURL & MISRA (1979). The present study was undertaken with a view to finding out if there was any ecological impact on chromosomes of *R. maidis* (Fitch).

MATERIAL AND METHOD

The samples of aphid *Rhopalosiphum maidis* (Fitch) (Subfamily - Aphidinae, tribe - Aphidini) were collected from the crop plants *Zea mays* and *Triticum vulgare* in the months of July 1980 and February 1981, respectively from Calcutta. The chromosome preparations were made from apterous viviparous females following the method of CHATTOPADHAY and RAYCAHUDHURI (1980).

RESULTS

Mitotic plates reveal the chromosome number 2n = 8 (Figs. 1-3) and this is in accordance with the earlier reports (SUN & ROBINSON, 1966; ROBINSON & CHEN, 1969; KURL & MISRA, 1979). However, we also found some plates with 10 chromosomes (Fig. 4). Furthermore, metrical analysis (Tables 1, 2 & 3) of the chromosomes prepared from the aphids collected from *Triticum vulgare* shows certain variation (Table 2) in respect of chromosome length from that collected from *Zea mays* (Table 1). Variation in respect of number (2n = 10) and length of chromosomes also exists (Tables 1 & 3) even within the same species infesting the same host plant.

However, the data provided in Table 1 further confirms the findings of earlier workers (ROBINSON & CHEN, 1969; KURL & MISRA, 1979).

DISCUSSION

The diploid chromosome number in *R. maidis* (Fitch) is 2n = 8 because the plates with 2n = 8 is more frequent than the plates having 2n = 10. This is in agreement with other works (SUN & ROBINSON, 1966; ROBINSON & CHEN, 1969; KURL & MISRA, 1979). BLACKMAN (1971) and GUT (1976) opined that intraspecific

TABLE 1. Karyotype analysis of *Rhopalosiphum maidis* (Fitch).

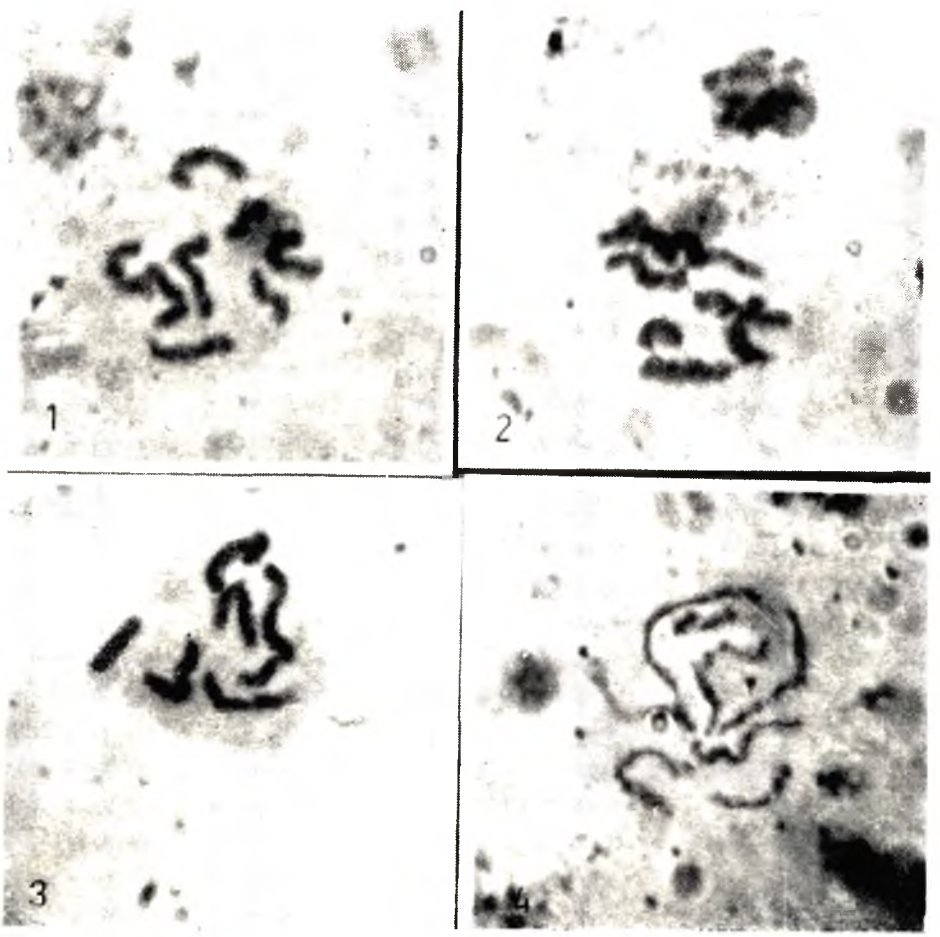
Cell No.	Name of the host plant	Season of collection		Actual length and relative length as a percentage of total complement length (TCL) Chromosome number.								
				1	2	3	4	5	6	7	8	TCL
1	*Zea mays*	July	μ	6.5	6.5	6.0	6.0	6.0	6.0	3.5	3.5	44
			%	14.77	14.77	13.63	13.63	13.63	13.63	7.95	7.95	
2	*Zea mays*	July	μ	6.0	6.0	6.0	5.8	5.8	5.0	3.5	2.0	40.1
			%	14.96	14.96	14.96	14.96	14.46	12.46	8.72	4.98	

TABLE 2. Karyotype analysis of *Rhopalosiphum maidis* (Fitch).

Cell No.	Name of the host plant	Season of collection		Actual length and relative length as a percentage of total complement length (TCL). Chromosome number.								
				1	2	3	4	5	6	7	8	TCL
3	*Triticum vulgare*	February	μ	8.0	7.5	7.0	7.0	5.0	4.2	3.4	2.0	44.1
			%	18.14	17.00	15.87	15.87	11.33	9.52	7.70	4.53	

TABLE 3. Karyotype analysis of *Rhopalosiphum maidis* (Fitch).

Cell No.	Name of the host plant	Season of collection		Actual length and relative length as a percentage of total complement length (TCL) Chromosome number										
				1	2	3	4	5	6	7	8	9	10	TCL
4	*Zea mays*	July	μ	10.1	10.0	9.5	9.0	9.0	5.5	5.1	5.0	1.8	1.8	46.8
			%	15.11	14.97	14.22	13.47	13.47	13.47	7.63	7.48	2.69	2.69	



Figs. 1—4. Photomicrograph of somatic metaphase plates of *R. maidis* (Fitch). Figs. 1—2. Showing 2n = 8, collected from *Zea mays* during July. Fig. 3 Showing 2n = 8 collected from *Triticum vulgare*, during February. Fig. 4. Showing 2n = 10 collected from *Zea mays*, during July.

variation in chromosome number exists in aphid. This idea further gains support from the observation in respect of the chromosome number i. e., 2n = 8 and 10 in *R. maidis* (Fitch). The chromosomes of *R. maidis* (Fitch) have been numbered (Tables 1, 2 & 3) according to HARPER & MAC DONALD (1966 & 1968) because homologous pairs of chromosomes could not positively be identified. However, KURL & MISRA claimed to have observed homologous pairs, yet they numbered them individually, the reason for which is not clear. All these findings would suggest that there are some inherent difficulties lying with the material in homologizing them. One of them is that there are several chromosomes almost of same size. This difficulty can only be avoided when banding technique could be applied.

ROBINSON & CHEN (1969) have opined that 6 out of 8 chromosomes are about the same size while the two are slightly shorter. It is apparent from the works of ROBINSON & CHEN (1969) and KURL & MISRA (1979) that the length of first three pairs of chromosomes has a gradual decreasing trend while the remaining two have become abruptly shortened. This corroborates fairly our data (Table 1).

However, material fixed in different seasons or from different host plants show variation in result. Thus chromosome material fixed in July from wheat show, a gradual decrease in length for all the four pairs of the chromosomes (Table 2).

The chromosomes of the cells having 2n = 10 can be grouped into three types, viz., (1) First type (Nos. 1—5) comparatively much longer than the others and shows a gradual decrease in length among themselves. (2) Second type (Nos. 6—8) shortened abruptly from the first type though shows the same trend in respect of length as observed earlier. (3) Third type (Nos. 9 & 10) of same length, but much shorter than others. Peculiarly enough the second and third types show the same (5%) decrease in length from the first and second type respectively.

From what has been stated above it would lead us to suggest that the host plants, so also the season, play a role on chromosome morphology. It may be pointed out that KURL & MISRA (1979) did not observe any such differences in the chromosome morphology of the aphids collected from different host plants. However, according to GUT (1976) such variations in chromosome structure and number are nothing unusual in aphids. The cell sap in the host plant may have some influence on the morphology of chromosomes.

Acknowledgements: The authors sincerely acknowledge Prof. K. C. GHOSH, Head of the department of Zoology, Calcutta University for extending laboratory facilities, and to Prof. G. K. MANNA, National fellow, Kalyani University for critically going through the manuscript.

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Entomon, 1982, *Vol.* 7, *No.* 4, *pp.* 447 *to* 450

EFFECT OF TEMPERATURE ON THE DEVELOPMENT, SURVIVAL AND FECUNDITY OF THE PREDATORY MITE, *AMBLYSEIUS TETRANYCHIVORUS* (GUPTA) (ACARINA : PHYTOSEIIDAE)

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(Received 31 August 1982)

The native predatory mite, *Amblyseius tetranychivorus* (Gupta) was exposed to three constant temperature levels *viz.*, 25°, 30° and 35°C to study the effect on development, survival and fecundity. The rate of development of all immature stages varied directly with temperature. Average total time taken for development was 166.20, 108.20 and 97.90 h at 25°, 30° and 35°C respectively. Adult gravid female survived on an average for 37.2, 32.2 and 11.5 days at 25°, 30° and 35°C respectively. Mean ovipositional period was greatly affected by different temperatures. Total fecundity was also affected. A mated female laid a mean total of 34.5, 47.8 and 2.8 eggs in 30.1, 23.8 and 2.0 days of reproductive period at 25°, 30° and 35°C respectively. Though higher temperatures favoured faster development in immature stages, survival, oviposition and fecundity of adults were greatly affected. Of the test temperatures 30°C was found to be optimum.
(*Key words:* phytoseiid mite, *Amblyseius tetranychivorus*, effect of temperature)

INTRODUCTION

Very little effort has hitherto been made in India to study indigenous predatory mites such as the Phytoseiidae. Phytoseiid mites are considered to have profound effect in the control of spider mite populations (CHANT, 1959; LAING & HUFFAKER, 1969; FLAHERTY & HOY, 1971) as these are able to act even at low pest population density. However the effectiveness of phytoseiids for controlling phytophagous mites depends upon their population increase over the pest which in turn is controlled by a number of abiotic and biotic factors. The population fluctuation of a species in nature is often closely related to changes in temperature. Therefore, in the present study, the effect of temperature on *Amblyseius tetranychivorus* (Gupta), a native mite predator, was studied using three constant temperatures. Studies were conducted with respect to the rate of development, adult survival, oviposition and fecundity.

Contribution No. 109/82 of the Indian institute of Horticultural Research, Bangalore - 560 080.

MATERIALS AND METHODS

The culture of *A. tetranychivorus* was initially maintained on host mite *Tetranychus ludeni* Zacher which itself was maintained on excised okra and brinjal leaves. Later, it was mass reared successfully under laboratory conditions on a specially designed rearing unit using pollen grains of castor, *Racinus communis* L. as an alternate food (KRISHNAMOORTHY, 1982). As there was no marked difference in the behaviour of the predatory mites or their level of fecundity when they were fed on castor pollen grains (unpublished data), the latter were used as food material in place of *T. ludeni*.

Three constant temperature regimes *viz.*, 25°, 30° and 35° ± 1°C were chosen for the study which was carried out in B. O. D. incubators, with the relative humidity ranging between 65 and 95 per cent.

Pre conditioning:

Well grown deutonymphs of both males and females of *A. tetranychivorus* were transferred on to the rearing units with fresh pollen grains from laboratory stock culture and held in a low temperature B.O.D. incubator, which was set to maintain the desired temperature. No artificial illumination was provided inside the incubator, but the absence of light was not known to have a dominant influence on the development, longevity or fecundity of the related species *A. chilenensis* (Dosse) at higher temperature regimes such as 25° and 32°C (Wei-Lan Ma & Laing, 1973). As soon as both the sexes attained adult stage, they were separated and released at the rate of two males to one female per small rearing unit (made up of petri-plates. Each unit was considered as one replicate.

Treatment:

Ten replicates were maintained at each test temperature. Observations were recorded on periods of pre-oviposition, oviposition and post-oviposition until death. Total nmuber of eggs laid per female during the reproductive period was also recorded.

From the rearing units held at each test temperature, a total of twenty individuals were collected in each developmental stage and kept separately to record the development time taken by each stage. Each individual was considered as one replicate. Ten eggs were held separately at each test temperature for recording total developmental period. Fresh pollen grains were offered every day. But for the short period, when the rearing units were removed from the incubator for microscopic observation they were not taken out of the incubators throughout the study period.

RESULTS AND DISCUSSION

Egg: The eggs of *A. tetranychivorus* are oval, translucent and much bigger than the spider mite eggs and can therefore be readily distinguished. Incubation period was observed to be reduced with the increase in temperature (Table 1). The shortest period was 38.40 h at 35°C, while it rose to 41 05 and 71.80 h at 30 and 25°C respectively.

Hexapod larva: Hatchability was found to be normal at all test temperatures. No feeding was observed. The larva took 22.90, 16.60 and 13.35 h at 25, 30 and 35°C respectively to complete its development (Table 1).

Protonymph: Feeding was observed from this stage onwards. Developmental period of this stage was less at higher than at lower temperature (Table 1).

Deutonymph: During the early part of this stage, males and females could not be readily distinguished, but later when the nymph had fed, the abdomen of the female appeared more elongate and

Table 1. Developmental period of immature stages of *A. tetranychivorus* at three constant temperature regimes.

Stage	Developmental time (h)*		
	25°C	30°C	35°C
Egg	71.80±1.68	41.05±1.00	38.40±1.1
Hexapod larva	22.90±1.65	16.60±0.69	13.35±0.69
Protonymph	31.80±1.15	26.25±0.46	24.40±1.54
Deutonymph	40.45±1.79	24.20±1.10	21.75±0.73
Total **	166.20±1.80	108.20±1.15	97.90±1.27

* Mean of 20 replicates ± SE ** Mean of 10 replicates ± SE

much larger than that of the male. Deutonymph stage lasted longer at lower than at higher temperatures (Table 1). It took 40.45 h at 25°C as against 21.75 h at 35°C.

Total developmental rate: High temperature favoured faster development of immature stages and reduced the total time taken to develop into adult. As seen in Table 1, at 25°C it was 166.20 h as against 97.90 h at 35°C.

From the results obtained it is clear that the rate of development was greatly influenced by the temperature. Similar inversely proportional relationship was also observed by WEI-LAN MA & LAING (1973) with the predatory mite *A. chilenensis*. Total developmental period for *A. tetranychivorus* was longer (about 6.92 days or 166.20 h) than for *A. chilenensis* (5.1 days) (WEI-LAN MA & LAING, 1973) and *Phytoseiulus persimilis* Athias-Henriot (5.37 days) (TAKAFUJI & CHANT, 1976) at 25°C.

Adult: Deutonymphs of females were invariably guarded by adult males. Mating took place almost immediately after female deutonymph attained adult stage. Mating was observed to be a prolonged process usually continuing over several hours. Females copulated repeatedly on the same day or successive days before and even, when actively reproducing. Multiple mating was found necessary for optimum egg production and oviposition as in the case of *Iphiseius degenerans* Berlese (TAKAFUJI & CHANT, 1976).

Pre-oviposition: Though at higher temperatures the pre-oviposition period was reduced, the same was greatly affected at 35°C (Table 2). Though some females mated once or twice, they did not lay eggs This sort of result may be due to the increased activity of both females and males at higher temperature, which in turn may have affected multiple mating. Lack of successive matings may have also been one of the reasons for prolonged pre-oviposition period.

Oviposition and longevity: The periods of oviposition and post-oviposition were also influenced by temperatures (Table 2). Higher temperature tended to reduce oviposition period and post-oviposition periods, and thereby reducing the total adult longevity.

Fecundity: Though higher temperatures favoured shorter ovipositional periods, total

TABLE 2. Duration of various periods in the adult life of *A. tetranychivorus* at three constant temperature regimes.

Particulars	Duration (days)*					
	25°C		30°C		35°C	
	Range	Mean	Range	Mean	Range	Mean
Pre-oviposition period	2.25—3.0	2.83	1.5—2.50	1.66	1.5—11.75	4.77
Oviposition period	15—48	30.1	15—31	23.8	0—9	2.0
Post-oviposition period	0—7	3.6	0—10	4.4	0—7	4.5
Total adult longevity	16—51	37.2	19—45	32.3	3—17	11.5

* Mean of 10 replicates.

TABLE 3. The fecundity of *A. tetranychivorus* at different temperatures in the presence of surplus food.

Particulars		Fecundity at		
		25°C	30°C	35°C
Total number of eggs/ female	Mean*	34.5	47.8	2.8
	Range	(15—41)	(36—58)	(0—10)

* Mean of 10 replicates.

number of eggs that a female could lay was drastically affected. From table 3 it is clear that at 35°C the females laid very few eggs as against at 30° and 25°C. Insufficient matings at 35°C may be one of the reasons for poor fecundity. Though the female lived longer and had longer ovipositional period at 25°C, the total number of eggs obtained at this temperature was also less than that obtained at 30°C. Low temperatue also did not favour fecundity.

On the whole, though higher temperature favoured faster development of all immature stages, adult survival and fecundity were adversely affected. From the experiments conducted, 30°C was found to be optimum for population increase of the predatory mite.

Acknowledgements: The auther is grateful to Dr. (Mrs) SUDHA NAGARKATTI, Senior Entomologist, All India Co-ordinated Research Project on Biological Control of Crop pests and Weeds, Indian Institute of Horticultural Research, Bangalore for critically going through the manuscript. He is also thankful to the Director, I. I. H. R., Bangalore for providing facilities to carry out the study.

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Entomon, 1982, *Vol.* 7, *No.* 4, *pp.* 451 *to* 456

A NEW GENUS OF ORIBATID MITE (ACARI : ORIBATEI) FROM MALABAR

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(Received 25 September 1982)

A new genus *Pelokylla* with *P. malabarica* sp. nov. as type species is described from Malabar, Kerala, India.

(Key words: Pelokylla malabarica, new genus and species)

Pelokylla gen. nov.

Diagnosis

Notogaster without punctations and with large number of unevenly arranged small areae porosae, numbering about or more than a hundred, lamellae conspicuously thick with large cuspis for lamellar setae, pteromorphae immovable, not very clearly projecting over the outline of the body. A pair of aggenital setae present, legs tridactylous.

Type species

Pelokylla malabarica sp. nov. (Figs. 1 and 2)

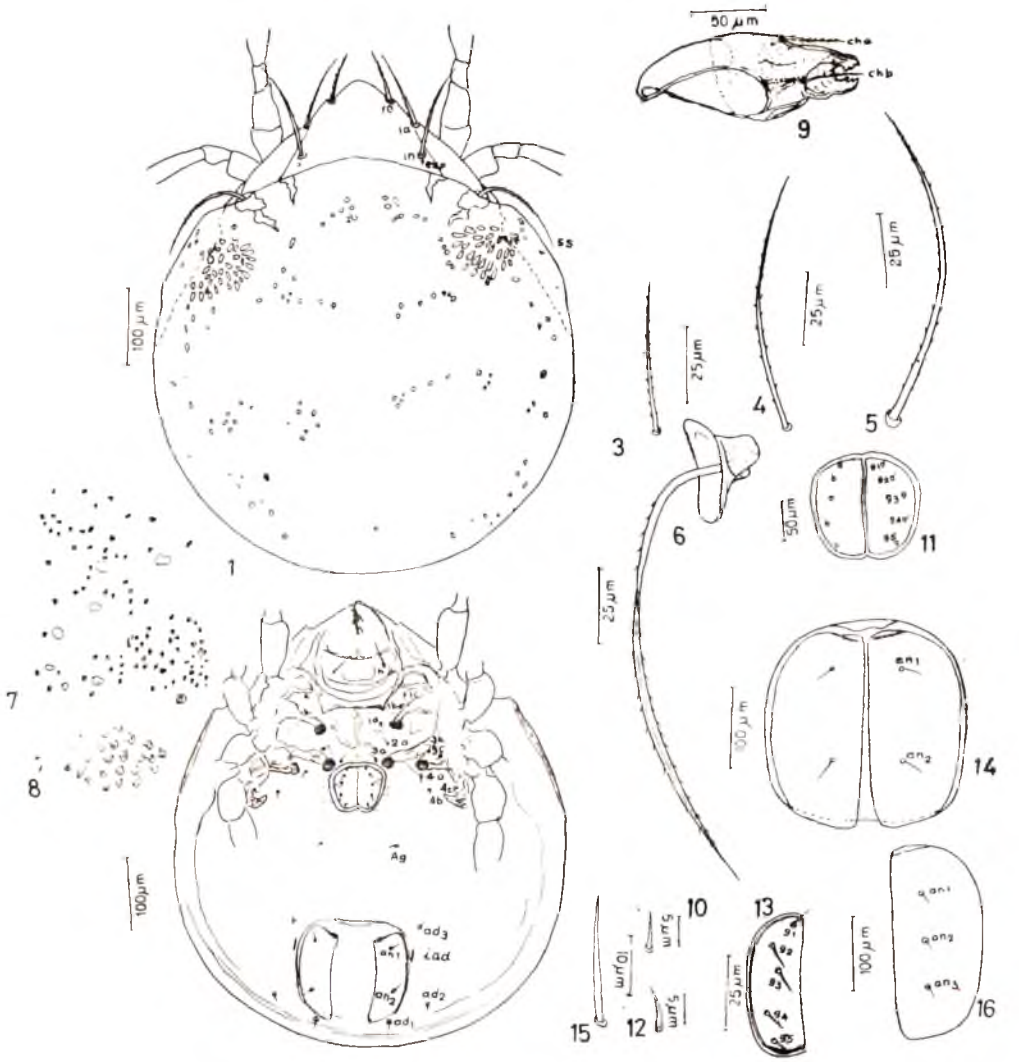
Rostral setae originating from well defined notches at the lateral margin of rostrum. Notogastral setae completely regressed or absent, epimeral boundaries one and four short, others comparatively long.

Colour

The colour of the adult collected from the field ranged from light to dark brown. Newly emerged adults brown in colour becoming darker with growth.

Prodorsum

Broader posteriorly and tapering anteriorly. In higher magnification, prodorsum appears to be inserted within the notogaster. Rostral setae (Fig. 3) 70 μm long originating from well defined notches at the lateral margin of the rostrum, anteriorly directed, pointed towards the tip and barbed on outer surface. Lamellar setae (Fig. 4) longer than rostral setae with 127.5 μm in length, inserted at the lamellar cuspis, inwardly curved and barbed on both sides. Lamellae broader at the base, converging anteriorly. The anterior tip of the lamellae end about one half above the length of the prodorsum. Interlamellar setae (Fig. 5), the longest of the prodorsal setae, 177.5 μm long weakly barbed on both sides and outwardly directed. The interspaces between rostral and lamellar and lamellar and interlamellar more or less the same. The posterior exobothridial setae seen on both sides. Anterior exobothridial setae could not be located. Sensillus serrated on both the sides, originating from the hollow cup like bothridium (Fig. 6). Due to the forward bending of the notogaster, the bothridial opening appears to be in the notogastral margin. A flattened ridge from the base of the bothridium to the notogastral region and a similar pair one on each side between the bothridium also present.



Figs. 1—16. *Pelokylla malabarica*. 1. Dorsal view; 2. Ventral view; 3. Rostral seta; 4. Lamellar seta; 5. Interlamellar seta; 6. Bothridium showing sensillus; 7. Tubercles on notogaster; 8. Areae porosae on notogaster; 9. Chelicera; 10. Epimeral seta; 11. Genital plates; 12. A genital seta; 13. A genital plate enlarged; 14. Anal plates; 15. An anal seta; 16. Anal plate showing asymmetry in setation.

Notogaster

Anteriorly converging and posteriorly rounded. Pteromorphae well extended in newly emerged adults, folded in well sclerotised animals. On the dorsal side near the origin of wings at anterolateral margin, a slit like *ia* present. Notogaster with projecting and regularly placed tubercles (Fig. 7) at the anterolateral region below the level of pteromorphae. In paratype, these show variations. Areae porosae (Fig. 8) found scattered throughout the notogaster without any specificity, seen more on anterolateral and posterolateral regions, numbering over hundred. Paratypes with more areae porosae, with different shapes. Notogastral setae completely regressed or absent.

Ventral region

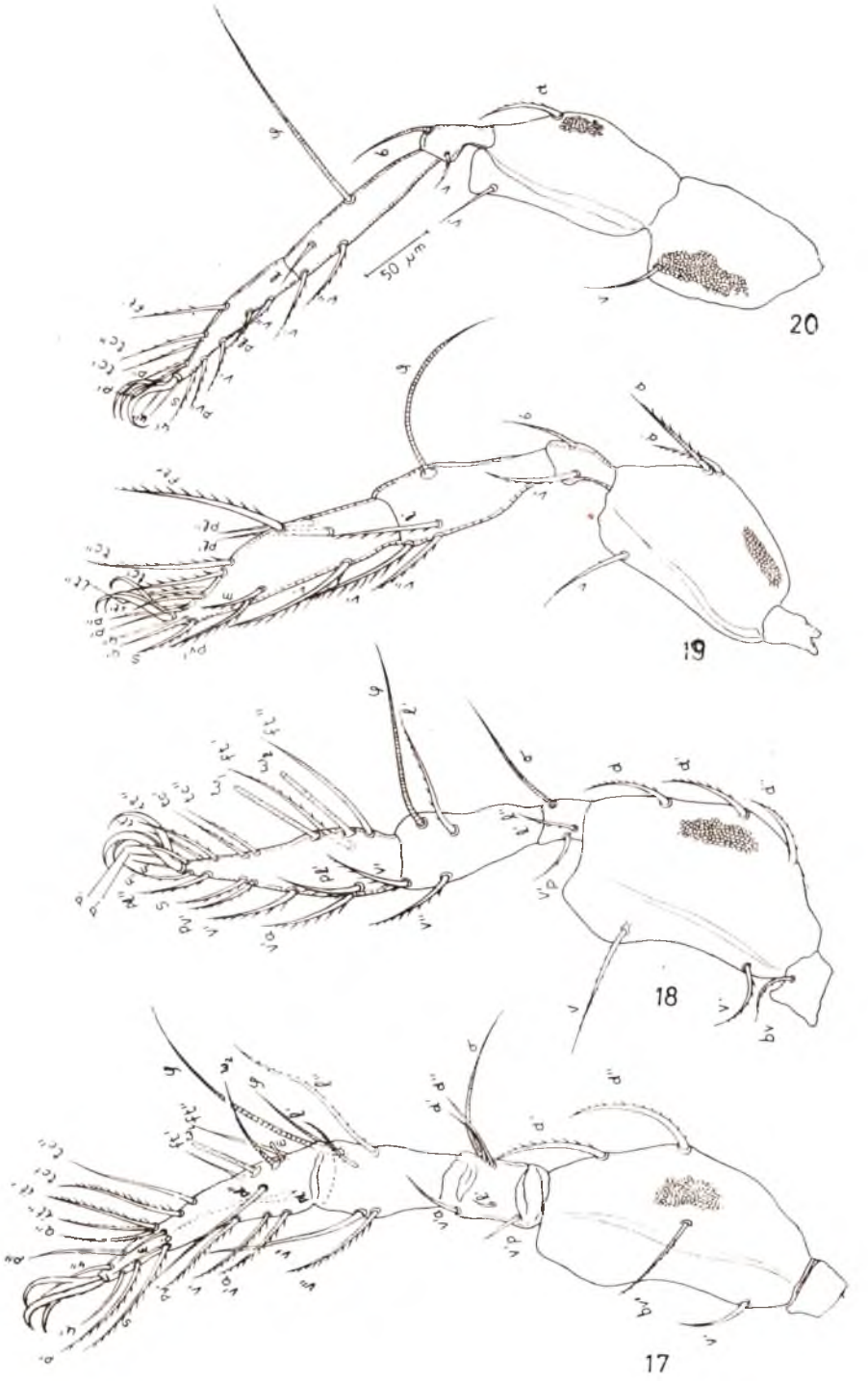
Gnathosoma typically invaginated with compressed lateral and posterior sides, bearing one pair of setae *h*. A ridge-like structure with two ends bent downwards below the gnathosoma. Chelicerae (Fig. 9) serrated with prominent teeth, the setae *cha* and *chb* long and barbed. Epimeral boundaries one and four short, others comparatively long. Epimeral setae (Fig. 10) small but clear in high magnification. Epimeral setal formula 3-1-3-3.

Genital and anal areas far removed from each other. Genital plates (Fig. 11) somewhat rounded with five pairs of thin setae arranged slightly laterally (Figs. 12 and 13).

Anal plates (Fig. 14) larger than genital plates with a pair of anterior and posterior setae (Fig. 15). Two paratypes show asymmetry with three anal setae (Fig. 16) instead of the normal number two. Of the three pairs of adanal setae, the first (Ad_1) is located posterior, second (Ad_2) lateral and third (Ad_3) anterior to the anal plates. The mutual distance between Ad_1 and Ad_2 about half that of Ad_2 and Ad_3. All ventral setae comparatively small, thin and smooth. A pair of slit like fissures, *iad* present at the anteroiateral regions of anal plate, just below Ad_3.

Legs

All legs (Figs. 17—20) are typically tridactylous without teeth the central claw thicker than the laterals. Most of the setae of legs normal, some with and others without serrations, in addition to few modified types serving as setiform organs, commonly found on the genu, tibia and tarsus. Among the five segments of the legs, the trochanter generally smaller except in leg 4, with very few setae, having only a single seta on the trochanter of legs 2 and 4. Femur of all legs broader with a keel like extension downwards. Tibia I carries the longest of the setiform organs, the tactile solenidion. Tarsus generally longer with maximum number of setae. The total number of setae distributed from trochanter to tarsus of legs 1-4 is 0-4-5-4-20 (including the famulus), 1-5-3-3-16, 0-3-1-3-15 and 1-2-1-3-12 respectively. Solenidial formula (genu to tarsus) of legs 1-4 is 1-2-2, 1-1-2, 1-1-0 and 1-1-0. Solenidia of tarsi 1 and 2 bacculifrom. Famulus 'e' of tarsus 1 short and straight, located behind w_2. Tibial solenidion of all legs filiform and longer than the respective segments. The solenidion of genu 1-4 filiform. The genu of all legs carry a solenidion each, but the number of setae show a regressive tendency (5-3-1-1) from genu 1-4. Majority of leg setae attenuate and barbed. Legs 1-4 show a gradual reduction in the number of setae. Setal differentiation of the four legs are given in the table. Polygonated microstructures present on the trochanter and femur of legs 1-3.



Figs. 17—20. Legs 1 to 4

TABLE 2. Table showing the relationship between the age and receptivity of female *Clania cramerii* (Westwood).

Age of female	No. of matings tried	1. Successful matings		2. Unsuccessful matings		3. Mating failures	
		Number	Percentage	Number	Percentage	Number	Percentage
0 — day	8	3	37.5	2	25.0	3	37.5
1 — day	8	7	87.5	1	12.5	0	0
2 — day	8	5	62.5	3	37.5	0	0
3 — day	8	5	62.5	2	25.0	1	12.5
4 — day	8	3	37.5	3	37.5	2	25.0
5 — day	8	3	37.5	2	25.0	3	37.5
6 — day	8	2	25.0	2	25.0	4	50.0
7 — day	8	1	12.5	1	12.5	6	75.0
8 — day	8	0	0	0	0	8	100.0
9 — day	8	0	0	0	0	8	100.0
Total	80	29		16		35	
Mean			36.25		20.00		43.75

were from 8 and 9 day old groups. Insects of these groups registered 0% receptivity. In the present study, as the status of the male, the environmental factors, etc., were not considered, the causes for the mating failures could not be assessed.

Influence of age on receptivity

The effect of age of female in attracting the male is given in Table 2. Though the adult female emerges with full number of eggs, it does not attract a male at once. It has been roughly estimated that 12 to 18 hours after (0-day old females as per the criterion already mentioned) emergence, it becomes receptive to mating. Within 6 hours after this period, 37.50% of matings were successful. The same percentage was observed for 4-day and 5-day old females. But the maximum percentage of receptivity was shown by 1-day old female, viz., 87.5%. Further, the table shows the order of response to mating with reference to age. *viz.*, 1, 2, 3, 4, 0 and 5, 6 and 7 and thereafter, no mating was observed. It is clear from the table that as the female aged, the attractiveness declined. The declining rate of attraction in the aged females may be attributed to the progressively reduced quantity of pheromone secretion.

Acknowledgements: We are grateful to Prof. E. P. MOHAMED ISMAIL, Principal, Jamal Mohamed College. Tiruchirapalli for his constant encouragement. Thanks are also due to Dr. M. H. RAVINDRANATH, School of Pathobiology, University of Madras and Dr. T. S. SARAVANAN, Asst. Professor, Jamal Mohamed College for their constructive advice in the preparation of the manuscript.

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Entomon, 1982, *Vol.* 7, *No.* 4, *pp.* 463 *to* 468

AN ESSENTIAL OIL FROM AUSTRALIAN BOTTLEBRUSH, *CALLISTEMON LANCEOLATUS* (MYRTACEAE) WITH JUVENOID PROPERTIES AGAINST THE RED COTTON BUG, *DYSDERCUS KOENIGII* FABR. (HETEROPTERA: PYRRHOCORIDAE)

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(Received 8 August 1982)

The essential oil obtained from the leaves of the Australian bottlebrush has been found to exhibit juvenoid properties. When applied topically on the ultimate larval instar of *D. koenigii* it produces different degrees of juvenilising effect both morphogenetic and gonadal and when applied on young allatectomised adult females, it promotes oocyte growth.
(Key words: essential oil, *Callistemon lanceolatus*, juvenoid)

INTRODUCTION

Eventhough juvenile hormone (JH) is a secretion of corpus allatum in insects, substances mimicking JH properties have been obtained from such diverse sources as the abdomen of the male cecropia silkmoth (WILLIAMS, 1956), various animal tissues (GILBERT & SCHNEIDERMAN, 1958; SCHNEIDERMAN & GILBERT, 1958) and plants (SCHNEIDERMAN *et al.*, 1960; SLAMA & WILLIAMS, 1965, 1966; BOWERS *et al*, 1966; CARLISLE & ELLIS, 1967; JACOBSON *et al.*, 1975; SAXENA & SRIVASTAVA, 1972, 1973: PRABHU & JOHN, 1975a, b). Most of the botanical juvenoids have been tested for their juvenilising properties but only a few (GOPAKUMAR *et al.*, 1977) for their gonadotropic properties. In this paper we report an essential oil obtained from the Australian bottlebrush, *C. lanceolatus* showing both these properties.

MATERIALS AND METHODS

Extraction of the essential oil

The essential oil was extracted from the shade-dried leaves of *C. lanceolatus* by steam distillation. The aqueous extract was shaken with sufficient quantity of ether, separated, dried over anhydrous sodium sulphate and concentrated on a water bath until there was no smell of the solvent. Half a kilogram of leaves yielded about 0.2 ml of golden yellow oil with characteristic aromatic odour.

Oil application and surgical techniques

Newly moulted V (ultimate) instar larvae of *D. koenigii* were sorted out from our laboratory colonies maintained at 25 ± 1°C, 16 h photoperiod and 75% relative humidity. For morphogenetic effects, doses of 10, 20, 50, 100 and 200 µg of oil in 1 µl of acetone per insect were topically applied on the larval wings with a microapplicator. Controls received 1 µl of acetone alone. Activity of the oil was scored from 0—3; 0, indicating no effect; 1, adultoids; 2, imperfect supernumerary VI instar; and 3, perfect supernumerary VI larva. The degree of juvenilisation was obtained by dividing the total score of the affected insects by the number of survivors in each treatment (PRABHU & JOHN, 1975). For gonadotropic effect, young (12 h old) adult females were water narcotised and allatectomised by the neck-membrane incision technique of SLAMA (1964). The allatectomised insects were divided into 2 groups: one (experimental) group receiving 200 µg of oil in 1 µl acetone per insect and the other (control) group, 1 µl of acetone alone. Insects were sacrificed after

7 days when controls of the first and experimentals of the second experiment had oviposited. Allatectomised insects showing vestiges of corpus allatum were excluded from our data.

OBSERVATIONS

Morphogenetic effects

Application of different doses of the oil of *C. lanceolatus* on the newly moulted V instar larvae of *D. koenigii* (Fig. 1) produced different degrees of juvenilising effect in the emerging adults. The dose of 10 μg had no effect (score 0, Fig. 2), 20 μg produced normal adults and adultoids (score 1, Fig. 3), 50 μg produced adultoids and imperfect supernumerary VI instars (score 2, Fig. 4), 100 μg produced adultoids, imperfect and perfect supernumerary VI instars (score 3, Fig. 5) and 200 μg produced only supernumerary VI instars, both imperfect and perfect. Raising the dose above 200 μg resulted in 100% mortality. Morphogenetic changes produced in the above categories of juvenilised insects are as follows: Adultoids have crumpled wings intermediate in length between the larva and adult, larval abdominal spots i. e., larval pattern of abdominal pigmentation and 3-segmented (adult) tarsi. The ovaries in females are as developed as in normal adults (Fig. 6). Imperfect supernumerary VI instars have

Fig. 1. Normal V instar larva. Fig. 2. Normal adult. Fig. 3. An adultoid. Fig. 4. Imperfect supernumerary IV instar larva. Fig. 5. Perfect supernumerary IV instar larva.

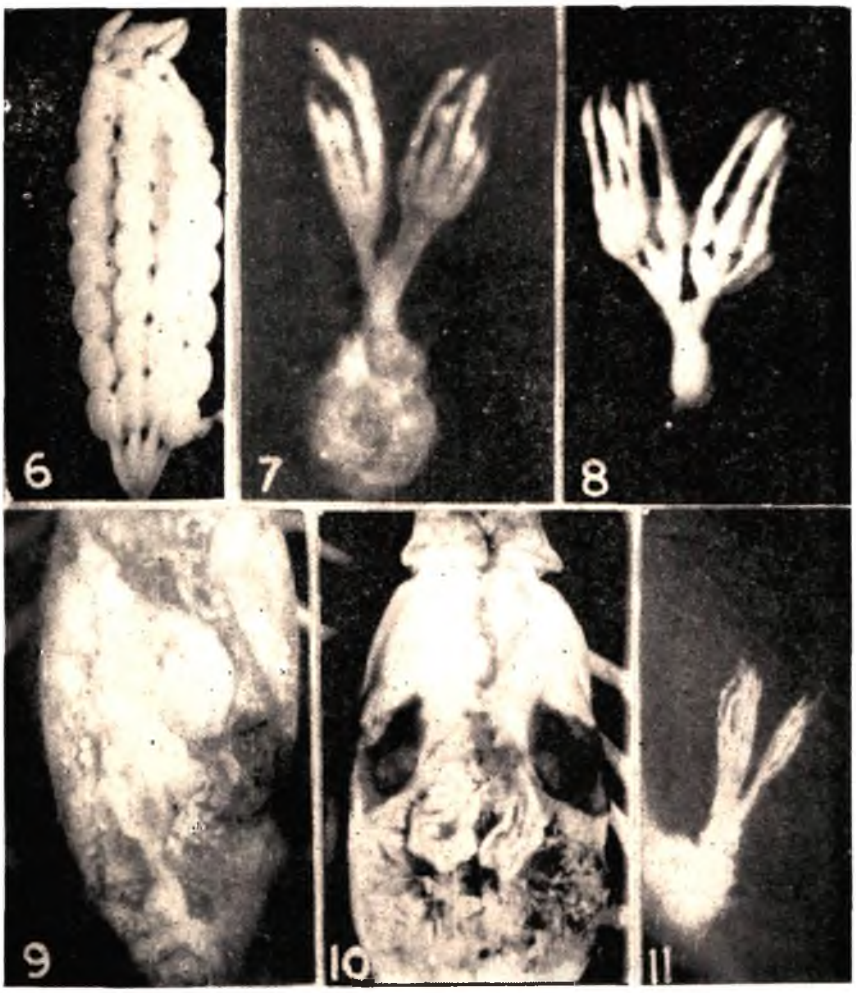

Fig. 6. Developed ovary of a normal (untreated) adult. Fig. 7. Underdeveloped ovary of an imperfect supernumerary VI instar larva. Fig. 8. Relatively more developed ovary of an imperfect supernumerary VI instar larva containing 1—2 mature oocytes. Fig. 9. Unilaterally detached ovary of an imperfect supernumerary VI instar larva. Fig. 10. Bilaterally detached ovaries of an imperfect supernumerary VI instar larva. Fig. 11. Immature ovaries of a perfect supernumerary VI instar larva.

fully larval (pad-like) wings, larval abdominal spots and 3-segmented tarsi. However, the female reproductive organs exhibit 3 types of developmental abnormalities: (1) the ovaries may remain underdeveloped lacking fully mature oocytes (Fig. 7); (2) may be better developed than (1) but bear fewer (1-2) mature oocytes (Fig. 8) as against 8-9 in normal adults (Fig. 6); and (3) may get detached from their efferent genital ducts on one (Fig. 9) or both sides (Fig. 10). In unilateral detachment, the detached ovary remains underdeveloped lacking mature oocytes while the intact one bears 2-3 mature oocytes. The efferent genital duct complex (comprising lateral and median oviducts, spermatheca and accessory glands) is present and oviposition, though reduced, occurs. On the other hand, in bilateral detachment, both the ovaries remain underdeveloped and the entire efferent genital duct complex is lost. Accordingly, there is no oviposition. Perfect supernumerary VI instars retain all the larval features *viz.*, larval (pad-like) wings larval abdominal spots, 2-segmented (larval) tarsi and completely immature larval ovaries (Fig. 11). The results of the experiment are summarised in Table 1.

Gonadotropic effect

Allatectomised (experimental) insects treated with oil had normal development of their ovaries and also laid the normal number of eggs while allatectomised controls treated with acetone alone had fully immature ovaries. The results of this experiment are summarised in Table 2.

TABLE 2. Gonadotropic effect of the oil of *C. lanceolatus* on adult females of *C. koenigii*.

Treatment	No. operated	No. survived	No. oviposited
Allatectomy + oil	34	23	23
Allatectomy + acetone (control)	12	8	1+

+ showed vestige of the corpus allatum

DISCUSSION

According to the generally accepted concept of neuro-endocrine function, the ultimate larval instar of an insect is able to transform into adult only in the absence of JH (WIGGLESWORTH, 1964). But if this hormone or its analogue is provided exogenously, the larva moults into a larval-adult intermediate (adultoid) or a

TABLE 1. Juvenilising effect of the oil of *C. lanceolatus* on the V instar larva of *D. koenigii*

Dose (μg)	No. treated	No. survived	Categories of juveniles: normal (0)	adultoid (1)	imperfect VI instar (2)	perfect VI instar (3)	Degree of juvenilisation
10	20	19	19	—	—	—	0/19 = 0
20	20	18	16	2	—	—	2/18 = 0.11
50	25	21	5	11	5	—	21/21 = 1.0
100	50	41	0	10	28	3	75/41 = 1.83
200	20	12	0	0	10	2	26/12 = 2.16
Control	20	19	19	—	—	—	0/19 = 0

Figures in parenthesis indicate scores.

supernumerary larval instar (SLAMA & WILLIAMS, 1965; SLAMA *et al.*, 1974). Since the oil of *C. lanceolatus* is capable of producing such juveniles and the degree of juvenilisation is dose-dependent as in many known juvenoids (BRANSBY-WILLIAMS, 1971; SEHNAL & SCHNEIDERMAN, 1973; DAOUD & SEHNAL, 1974) the former can be regarded as a true juvenoid (or a juvenoid-containing oil). This is further indicated by its ability to suppress the development of ovaries in the larva and promote their growth in the adult, the two mutually opposite roles that the juvenoids are credited to perform in the larval and adult stages of an insect (SLAMA *et al.*, 1974).

While inhibition of the larval ovaries by juvenoids is well known and considered as a part of the general inhibition of metamorphosis (SLAMA *et al.*, 1974), there is only one report though without details by SEHNAL (1976) on ovarian detachment from their genital ducts as a result of juvenoid treatment similar to the one we observe in the present insect. In an effort to find an explanation for this phenomenon, we performed parallel experiment with a known synthetic juvenoid (generously provided by Dr. SEHNAL) and observed that the adults emerging from the juvenoid treated larvae either retained their thin larval oviducts or had detached ovaries. From these results we are inclined to conclude that the larval oviducts like the larval ovaries are also suppressed by the juvenoid (as a part of the general inhibition of metamorphosis) and subsequently atrophy (possibly due to the changed internal milieu of the adult). The reason for the loss of the efferent genital duct complex in bilateral detachment of ovaries could be found in the experiments of REGIS (1977) who transected one of the oviducts in the 5th instar larva of *Triatoma infestans* and prevented maturation of the detached ovary. From this he concluded that gonadal-genital pathway communication was essential for the normal development of the ovaries. We believe that such a communication at least on one side is also necessary for the maintenance of the efferent genital duct complex. Finally, promotion of ovarian growth by the oil of *C. lanceolatus* in allatectomised insects shows its gonadotropic property as well.

Acknowledgements: We wish to thank Prof. M. S. KANUNGO, Head of the Department, for providing working facilities and the UGC for financial support.

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Entomon, 1982, *Vol.* 7, *No.* 4, *pp.* 469 *to* 473

LABORATORY EVALUATION OF INSECT GROWTH REGULATING COMPOUNDS AGAINST MOSQUITOES

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The efficacy of two chitin-synthesis inhibitors *viz.*, Diflubenzuron and Penfluron was assessed against *Aedes aegyptii, Culex quinquefasciatus, Anopheles stephensi* and *A. culicifacies* by treating them continuously at second, third or fourth instar larvae till pupation. *A. culicifacies* was found to be highly susceptible to both the compounds. Penfluron was almost equally effective against all the four species of mosquitoes tested while diflubenzuron proved to be more effective against Anophelines only.

The insect growth regulating compounds (IGR's) are unique for their greater selectivity of action, absence of undesirable effects on man, environment and wildlife and compatibility with modern insect pest management principles (WILLIAMS, 1956). Field tests with IGR compounds have been successful against housefly (ABLES *et al.*, 1975) and black fly (LACEY & MULLA, 1979). They have been shown to depress chironomid midge population (ALI & LORD, 1980). A large number of IGR compounds have been evaluated against different species of mosquitoes (MULLA *et al.*, 1974, 1975; HSEIN & STEALMAN, 1974; MULLA & DARWAZEH, 1976, 1979; SELF *et al.*, 1978; SHARMA *et al.*, 1979; AXTELL *et al.*, 1980). Among insect growth regulators, chemicals which interfere with chitin synthesis in insects are considered to be very promising. The objective of the present investigation was to evaluate the efficacy of two benzamide chitin synthesis inhibitors *viz.* diflubenzuron (DFB) and penfluron (PF) in *Aedes aegypti, Culex quinquefasciatus, Anopheles stephensi* and *A. culicifacies*.

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MATERIALS AND METHODS

The mosquito larvae were drawn from colonies of Delhi strains of *Ae. aegypti* and *C. quinquefasciatus* established in the insectary since 1965 and from colonies of *A. stephensi* and *A. culicifacies* raised from blood fed females collected from Delhi and Haryana respectively since 1981. The colonies were maintained at 27 ± 2°C and 80 ± 5% RH and provided with 14 h of artificial daylight using an electronic dimmer. The compounds diflubenzuron (1-(4 chlorophenyl) -3- (2-6 difluorobenzoyl) urea) and penfluron (2-6-difluoro. N-(4-trifluoromethyl phenyl) - amino carbonyl benzamide) were 90% pure and were supplied by Dr. A. B. BORKOVEC, USDA, Beltsville, U. S. A. 1% stock solutions of the compounds were made in acetone.

Synchronously hatched second, third and fourth instar larvae were used separately. Tests were performed in 16 oz glass jars containing 250 ml dechlorinated tap water. Desired concentrations were obtained by adding 0.1 ml of acetone solution of the compound. Same quantity of acetone alone was used in control. Fifty larvae were introduced into each jar. Each concentration had 4 replicates with appropriate controls. The larvae kept in these jars till

pupation were provided with food on alternate days. Mortality counts were recorded every 24 h. On pupation they were isolated and transferred to separate cages for adult emergence. Pupal mortality and adult mortality at the time of emergence were also recorded. From the total mortality, corrected mortality was calculated using Abbott's formula. The mortality data was plotted on log-probit paper and the LC_{50} and LC_{90} values were estimated from the dosage-mortality regression lines.

RESULTS

Continuous treatments of second, third or fourth instar larvae till pupation with DFB and PF caused different rates of mortality in larval, pupal and adult stages. Data on the cumulative mortality in four species of mosquitoes are presented in Table 1. Immature stages were found to be most susceptible as evident from the gradual decrease in susceptibility from second instar to fourth instar.

When the LC_{50} levels (Table 2) of different species of mosquitoes were compared it was found that DFB was more effective in Anophelines than in Culicines. Among them *A. culicifacies* was about 10 to 85 times more susceptible to DFB for the various larval instars as compared to *A. stephensi*. Larvae of *Ae. aegypti* were most tolerant to DFB among the mosquitoes tested and it was 100 times as tolerant as *C. quinquefasciatus* to DFB.

Unlike DFB, penfluron was generally toxic to all the species of mosquitoes tested (Tables 1 & 2). However, *A. stephensi* proved to be slightly more tolerant to PF than to the other species. LC_{50} levels of other species were almost identical. It is also apparent from the LC_{50} data of *C. quinquefasciatus* and *A. culicifacies* that PF appears to be almost equitoxic to both of them.

In general, the treatments did not cause much mortality in pupae. When the second and third instar larvae were treated, the mortality occurred mostly in the larval stage at the time of moulting and the adult emergence rate or mortality was comparatively less. However, when fourth instar larvae were treated the total mortality accounted was equally due to larval and adult mortalities.

DISCUSSION

It is evident from the present data that *A. culicifacies* is highly susceptible to both DFB and PF. Also PF proved to be more effective than DFB in causing higher mortality in life stages of all the four species of mosquitoes though DFB was more effective only in Anophelines. Similarly WELLINGA *et al.* (1973) reported that 0.03 to 1 ppm dichloro analogues of benzoyl phenyl ureas gave 90 to 100% mortality with the first instar larvae of *Ae. aegypti*. However, larvae of DDT-resistant *Ae. aegypti* and organophosphorus-resistant *C. tarsalis* and *C. p. quinquefasciatus* failed to pupate when treated with 0.001 to 0.005 ppm diflubenzuron (JAKOB, 1973). In the present studies Diflubenzuron was found to be more toxic to *C. quinquefasciatus* than to *Ae. aegypti*. MULLA *et al.*, (1974) found LC_{50} for diflubenzuron against *C. p. quinquefasciatus* was 0.0006 ppm when fourth instar larvae were treated. Similarly, SHARMA *et al.* (1979) found LC_{50} value of 0.0005 ppm when late third or early fourth instar larvae of *C. p. fatigans* were treated. The susceptibility of *A. culicifacies* to DFB is remarkable as in *A. albimanus* LC_{90} value of DFB was 0.001 ppm against fourth instar larvae (MULLA *et al.*, 1974). Penfluron proved to be a better insect growth regulator than DFB as it could cause higher mortality in all the species of mosquitoes tested. In both the cases the mortality occurred at the intermoult periods indicating that these compounds

TABLE 1. Percentage cumulative mortality in different life stages of mosquitoes treated at second, third and fourth instar larvae continuously till pupation with diflubenzuron and penfluron.

Diflubenzuron				Penfluron			
Concentration ppm	Second instar	Third instar	Fourth instar	Concentration ppm	Second instar	Third instar	Fourth instar
(a) *Ae. aegypti*							
0.008	1.0	1.5	0	0.00016	10.0	6.9	0
0.016	19.4	0.5	0	0.00032	43.5	19.1	0
0.032	43.4	16.0	0	0.00064	68.0	66.5	26.0
0.064	66.3	43.5	17.0	0.00125	82.5	74.5	50.6
0.125	100.0	68.5	42.0	0.0025	90.5	94.7	67.2
0.25	—	100.0	97.0	0.005	100.0	100.0	91.4
0.5	—	—	100.0	0.01	—	—	100.0
(b) *C. quinquefasciatus*							
0.00016	17.0	12.7	2.0	0.00016	24.5	34.3	0
0.00032	41.2	17.3	13.0	0.00032	59.4	38.4	15.4
0.00064	73.6	30.7	18.0	0.00064	69.8	64.6	24.2
0.00125	87.4	55.3	38.0	0.00125	100.0	77.8	42.9
0.0025	100.0	76.9	57.0	0.0025	—	92.4	60.9
0.005	—	96.91	82.0	0.005	—	100.	89.6
0.01	—	100.0	92.0	0.01	—	—	100.0
0.02	—	—	100.0				
(c) *A. stephensi*							
0.00025	3.0	7.0	0	0.0005	13.0	0	0
0.005	7.0	1.0	0	0.001	37.0	9.0	3.0
0.001	33.0	25.0	1.0	0.005	29.0	87.0	52.0
0.005	41.0	20.0	24.0	0.008	100.0	100.0	94.0
0.008	100.0	50.0	38.0	0.1	—	—	100.0
0.01	—	100.0	66.0				
0.05	—	—	100.0				
(d) *A. culicifacies*							
0.00003	3.0	5.0	2.0	0.00006	9.0	0	0
0.00006	26.0	18.0	19.0	0.00012	16.0	1.0	7.0
0.00012	42.0	55.0	34.0	0.00025	50.0	8.0	28.0
0.00025	80.0	77.0	50.0	0.0005	94.0	70.0	78.0
0.0005	100.0	100.0	94.0	0.0008	100.0	87.0	100.0
0.001	—	—	100.0	0.001	—	100.0	100.0

TABLE 2. Susceptibility of mosquitoes to diflubenzuron and penfluron when larvae were treated continuously till pupation.

		LC_{50}—LC_{90} (ppm)		
(1)	*Ae. aegypti*	Second instar	Third instar	Fourth instar
	Diflubenzuron	0.04 — 0.097	0.08 — 0.3	0.1 — 0.19
	Penfluron	0.00052 — 0.00175	0.00064 — 0.0019	0.00125 — 0.0045
(2)	*C. quinquefasciatus*			
	Diflubenzuron	0.0004 — 0.0014	0.001 — 0.0047	0.0017 — 0.0074
	Peufluron	0.00035 — 0.00155	0.00043 — 0.0021	0.0013 — 0.0052
(3)	*A. stephensi*			
	Diflubenzuron	0.0015 — 0.0048	0.0038 — 0.01	.0086 — 0.016
	Penfluron	0.00125 — 0.0032	0.0022 — 0.0042	0.0038 — 0.008
(4)	*A. culicifacies*			
	Diflubenzuron	0.00011 — 0.00025	0.00012 — 0.0003	0.00016 — 0.00035
	Penfluron	0.0002 — 0.00042	0.00042 — 0.0006	0.00025 — 0.0004

inhibited chitin synthesis during the moulting stage.

Acknowledgements: The authors wish to express their gratitude to Dr. A. B. BORKOVEC, United States Department of Agriculture, Beltsville, Maryland, USA for the generous gift of the IGR compounds. Financial assistance to the first author by the Council of Scientific and Industrial Research in the form of Junior Research Fellowship is also gratefully acknowledged.

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Entomon, 1982, *Vol.* 7, *No.* 4, *pp.* 475 *to* 479

TAXONOMIC NOTES ON A NEW SPECIES OF *TRICENTRUS* STAL (MEMBRACIDAE : HOMOPTERA) AND ITS IMMATURE STAGES

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(Received 15 January 1981)

Description of a new species of Membracidae, *Tricentrus spathodei*, and its immature stages is presented.

(Key words: description, *Tricentrus spathodei* n. sp., immature stages)

Tricentrus spathodei n. sp.

Female:

General colouration greyish brown. Head thrice as wide as long, obliquely directed backwards, densely pilose with long silvery hairs; upper margin of vertex slightly arcuate and sinuate; eyes light brown, subspherical, projecting outwards; ocelli hyaline, closer to each other than from eyes and located above the centro-ocular line; frontoclypeus longly sparsely pilose, extending about one half of its length below lower margin of vertex, frontoclypeal lobes fused, pronotum light brown, densely pilose with punctulations especially at the bases of suprahumerals; metopidium slightly obumbrant, nearly vertical, much wider than high, supra-ocular callosities black, divided, humeral angles light brown prominent, tips subacute; suprahumeral horns dark brown; robust, densely pilose with silvery hairs, much flattened, nearly as long as width between their bases, obliquely directed forwards and outwards, their apices broadly obliquely truncate and turned backwards, anterior carina weakly developed, dorso-posterior carina strongly ridged; posterior process stout, anteriorly broad, tapering behind to an acute point beyond middle, dark brown with a very light brown area in the anterior mid-dorsal region, posterior one-third pitch black, central carination fine and percurrent through metopidium, lateral carinations weak, tip slightly curved upwards and reaching the anal angles of tegmina, rest of posterior process impinging on tegmina. Tegmina hyaline, thrice as long as wide, basal region coriaceous, dark brown, punctuate, veins light yellow, R_1, rs and part of the veins bordering first and fifth apical cells pitch black, costal margin extremely thickened, chitinised, absorbing part of R_1 and extending well into the first apical cell; first discoidal cell slightly longer than the second; apical limbus moderately broad; wings with three apical cells; scutellum typical for the genus; legs uniformly greyish brown. Abdomen dark brown, terminalia pitch black.

Measurements: Length from frontal margin to tips of tegmina 6.0 mm., to tip of posterior process 4.0 mm.; width across tips of suprahumerals 3.8 mm., at humeral angles 2.5 mm., at eyes 2.35 mm.

Male:

Similar to female but shorter. Abdominal terminalia typical for the genus.

Measurements: Length from frontal margin to tips of tegmina 4.9 mm, to tip of posterior process 3.3 mm; width across tips of suprahumerals 3.0 mm, at humeral angles 2.2 mm, at eyes 2.2 mm.

Immature stages

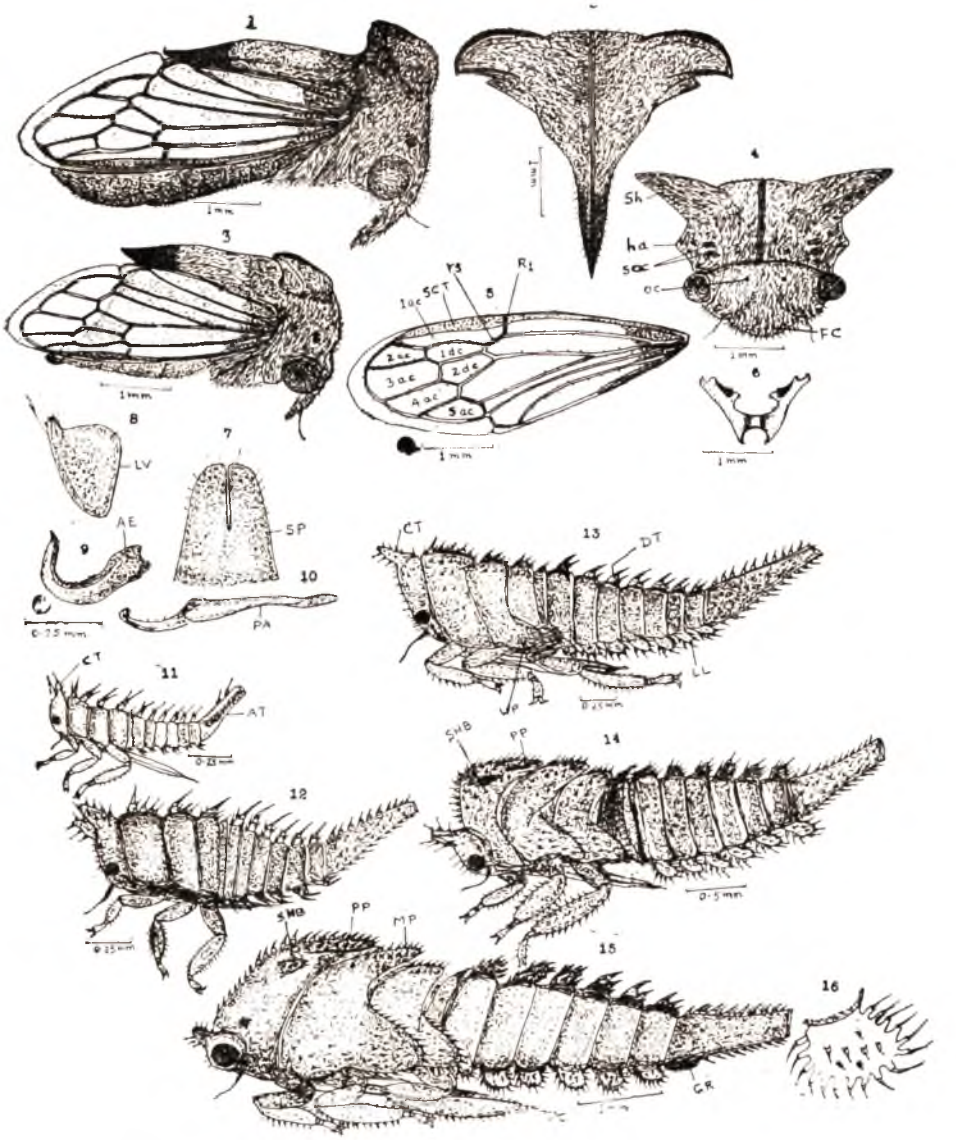
First instar nymph: Length 1.25 mm; body subcylindrical, yellowish brown, legs light brown with black patches. Head comparatively large, about two-thirds of the length of prothorax, cranial tubercles prominent, broadly conical, each tipped with a long spine besides two subspines near base; vertex truncate at base; ocelli inconspicuous; eyes small, light brown with two projecting setae; rostrum stout, long, extending upto the 6th abdominal segment. Thorax slightly shorter than abdomen excluding anal tube; prothorax as wide as long, protergite with two pairs of dorsal tubercles, the posterior one of which is directed backwards, each tubercle terminating in a long hair; meso- and metathoracic tergites more or less of equal length, each with a pair of tubercles terminating in two long hairs; first abdominal segment obsolete, second very narrow with a pair of short dorsal tubercles, 3rd to 8th segments identical, each with a pair of dorsal tubercles tipped with a long slender spine directed backwards besides a shorter spine; lateral lamellae of segments 3-8 short, each lamella bearing a pair of backwardly inclined spines; anal tube about one-third of total body length bearing a postmedian and a subterminal tuberculate spines dorsally.

Second instar nymph: Length 1.8 mm; body much stouter than the first instar; general colouration light brown. Head dark brown with cranial tubercles more prominent than in the preceding stage and bearing many small tuberculate spines; tip of rostrum reaching the fifth abdominal segment; dorsal tuberculated spines on thoracic tergites prominent; abdominal tergites as in first instar, but the lateral lamellae on segments 3-8 more prominent; anal tube about one-third of total body length, bearing four or five linear rows of tuberculate spines.

Third instar nymph: Length 2.84 mm; colouration as in second instar; body dorsoventrally compressed; head wider than long; cranial tubercles larger than in the preceding stage and bearing many short spines; rostrum reaching the fourth abdominal segment. Thorax nearly as long as wide, dorsal tuberculated spines arranged in two linear rows; wing pads clearly visible, fringed with short hairs; abdominal segments 3-8 with stout dorsal tubercles tipped with spines, basal region of tubercles black; lateral lamellae more pronounced than in 2nd instar, inclined backwards and bearing 4-5 long tuberculated spines besides subspines scattered over; anal tube slightly less than one-third of body length.

Fourth instar nymph: Length 3.8 mm, colouration brown with dark spots scattered

ABBREVIATIONS. 1 ac-5 ac—apical cells 1 to 5; AE—aedeagus; AT—anal tube; CT—cranial tubercle; 1 dc—first discoidal cell; 2 dc—second discoidal cell; DT—dorsal tubercle; FC—frontoclypeus; GR—genitalic rudiments; ha—humeral angle; LL—lateral lamella; LV—lateral valve; MP—mesonotal process; oc—ocellus; PA—paramere; PP—pronotal posterior process; R_1—first branch of radius; rs—radial sector; SCT—thickening of costa-subcosta; Sh—suprahumeral horn; SHB—suprahumeral bud; SOC—Supraocular callosity; SP—subgenital plate; WP—wing pad.



Tricentrus spathodei n. sp. 1. Female lateral view; 2. Dorsal view of pronotum of female; 3. Male lateral view; 4. Frontal view of head and pronotum of female; 5. Tegmina; 6. Scutellum; 7—10. Parts of male genitalia; 11. First instar nymph; 12. Second instar nymph; 13. Third instar nymph; 14. Fourth instar nymph; 15. Fifth instar nymph; 16. Abdominal lateral lamella of fifth instar nymph.

Fig. 17. Dorsal view of fifth instar nymph.

dorsally. Body dorso-ventrally compressed, head wider than long, obliquely directed backwards, rostral tip reaching the 2nd abdominal segment; cranial tubercles large proportionate to the size of the head and equipped with tuberculate spines; eyes prominent pronotal posterior proces densely spinose, extending caudad over mesonotum; buds of suprahumeral horns distinct; wingpads prominent with costal angles well defined; mesonotum produced backwards over metanotum. Abdomen nearly twice as long as thorax, dorsoventrally compressed; dorsal tubercles on abdominal segments 3-8, broad-based and black, bearing a cluster of short tuberculate spines; lateral lamellae broad, spathulate, bearing 7-8 tuberculate spines; anal tube less than one-third of total body length.

Fifth instar nymph: Length 6.4mm including anal tube; body very much compressed dorsoventrally; general colouration greyish brown with black dots scattered dorso-laterally; head nearly two and a half times as wide as long, cranial tubercles persistent as long, conical processes bearing tuberculate spines; vertex planate at base, eyes large, protruding, dull white; ocelli conspicuous, nearer to each other than to the eyes and situated above centro-ocular line; rostrum reaching the hind coxae. Thorax shorter than abdomen excluding anal tube; metopidium obliquely sloping backwards with a double row of tuberculate spines; lateral angles of pronotum broadly rounded; pronotal posterior process beset with dense tuberculate spines and gradually tapering behind over mesonotum; suprahumeral buds black, more prominent than in 4th instar and directed backwards; mesonotum about three-fourths as long as pronotum, its process long, tapering backwards over metanotum, finely tuberculate with spines; metanotum shorter than mesonotum, sparsely pilose; tegminal wingpads extending upto the 2nd abdominal segment and hind wing-pads extending to the 3rd segment; costal angles of wing pads broadly rounded and fringed with fine setae. Tibiae with linear rows of tuberculate spines; abdominal tergites 3-8 uniform, laterally extended and bearing long, flat lateral lamellae, each lamella beset with 14-16 tubercular spines inclined backwards besides shorter subspines scattered; lateral lamellae of 3rd segment shorter than those of the following segments; dorsal tubercles on segments 3-8 are large, broad-based, black, bearing many tuberculate spines; genitallic rudiments distinctly visible; anal tube about one-fourth of the total body length.

Host plant: Spathodea campanulata Bexuv.

Holotype : ♀; Allotype ♂; **Paratypes** 41 ♀♀ and 6 ♂♂; Nepionotype Fifth nymphal instar and numerous early nymphs, INDIA: Kerala, Trivandrum, 29.ix.1981.

Remarks: In the presence of broad, robust suprahumerals with obliquely truncate apices, *Tricentrus spathodei* resembles

T. cuneatus Distant (1908), and in the presence of a posterior process with projecting apex it comes close to *T. subangulatus* Dist. (1908). It differs from both these species in the pitch black colour of the posterior one-third of the posterior process, and also in the nature of the tegmina which shows a very broad chitinous thickening in the costal margin facing the 1st apical cell partly absorbing the R_1, and also in the characteristic pitch black colour of R_1, rs and part of the veins bordering the 1st and 5th apical cells, contrasting distinctly with the very light yellow colour of the other veins of the tegmina.

Acknowledgements: Thanks are due the I C A R, New Delhi, for the award of a Research Grant during the tenure of which this investigation was carried out.

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Entomon, 1982, *Vol.* 7, *No.* 4, *pp.* 481 *to* 485

INFLUENCE OF FOOD QUALITY ON REPRODUCTION AND LONGEVITY OF *CRYPTOPYGUS THERMOPHILUS* (ISOTOMIDAE : COLLEMBOLA)

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Under experimental conditions *Cryptopygus thermophilus* survived and reproduced when fed at 30 ± 1°C with four different type of food materials like baker's yeast, the fungus *Agaricus* sp., decaying leaves of the jack fruit tree (*Artocarpus integrifolia*) and decaying leaves of *Eupatorium* sp., the latter three food types being obtained from the habitat of the insect. Employing the technique of analysis of variance it was observed that the influence of the quality of food (in the above order of the food types) was very high on mean clutch size (39.93 eggs, 32.63 eggs, 19.53 eggs and 19.7 eggs respectively per female) $F = 114.3$; on the mean logevity of the female (139.29 days, 119.9 days, 111.9 days and 64.6 days respectively) $F = 98.75$; on mean fecundity (489.3 eggs, 365.6 eggs, 230.2 eggs and 106.0 eggs per female respectively) $F = 50.12$ and on mean reproductive period of the female (106.3 days, 87.7 days, 83.9 days and 35.1 days respectively) $F = 42.28$, all F values being significant at 1% level, while the ifluence was appreciably high on the mean number of ovipositions (12.8, 12.4, 12.7 and 5.3 respectively) $F = 10.53$, significant at 5% level. Yeast was apparently the most suitable food and *Eupatorium* leaf diet was least suitable, while the fungus, *Agaricus* sp., and decaying leaves of *Artocarpus* were having intermediate levels of suitability. One possible ecological consequence of the influence of the two leaf diets is that *C. thermophilus* can be expected to maintain a comparatively high population in a site dominated by *Artocarpus integrifolia* compared to a site dominated by *Eupatorium* sp.

(*Key words:* Collembola, *Cryptopygus thermophilus*, biology, yeast, leaf diet, reproduction, longevity)

INTRODUCTION

Diverse environmental factors are known to influence the reproductive phenomena and life of Collembola (CHRISTIANSEN, 1964; BUTCHER *et al.*, 1971) of which the influence of the quality and quantity of food is necessarily decisive. Presuming that in nature plently of food is available for Collembola, at least during the favourable season, it would be valuable to have an idea of the influence of the quality of food on reproduction and duration of life of these insects. Previous study on the food of tropical Collembola indicated some amount of diversity in the food habits of these insects (MURALEEDHARAN & PRABHOO, 1978) but the above study did not cover the assessment of food suitability and hence the present study was planned in *Cryptopygus thermophilus*, a collembolan having cosmopolitan distribution. In this study a comparison is made of three types of food materials available in the habitat of the insect with yeast, which is a standard food substance on which Collembola in general are reared in laboratory studies.

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MATERIALS AND METHODS

Live animals were obtained from an abandoned field at Kariavattom from soil and litter by dry funnel extraction method. They were kept in plastic containers with plaster of Paris-charcoal base (SNIDER *et al.*, 1969) with baker's yeast as food and a stock culture was developed, acclimatised to laboratory conditions.

For experimental purposes pairs of freshly laid eggs from the stock cultures were transferred to smaller culture vials (4 × 3.5 cm). Vials which happened to contain a male and a female were kept in a large glass walled chamber with blinds to control the light and maintained in the laboratory temperature 30 ± 1°C. Food materials offered were baker's yeast pellets, the fungus *Agaricus* sp.. decaying leaves of jack fruit tree *(Artocarpus integrifolia)* and decaying leaves of *Eupatorium* sp., a weed, the latter three being obtained from the field. Food was changed every third day and the plaster of Paris base was kept saturated with moisture. Observations were made twice daily. Influence of the food quality on various aspects of biology was statistically analysed employing the technique of analysis of variance (ANOVA).

OBSERVATIONS

Female *C. thermophilus* attained sexual maturity after the fifth moult and the sixth instar began to oviposit. Eggs were generally laid in a cluster. Each oviposition was preceded by a moult, rarely an adult moult was not followed by an oviposition during the reproductive period. Table 1 gives data on various aspects of biology of the insect studied here. Quality of food evidently influenced total number of ovipositions. Variations in the mean clutch size under the above conditions was very significant. Similarly significant differences were noted in the mean fecundity. Quality of food, however, did not affect appreciably the embryonic and post-embryonic development. The incubation period, first, second and third instar were respectively 3.4, 3.0, 2.5 and 2 days' duration on different types of food. Duration of the fourth instar was 2.0 days on yeast, and 1.5 on other foods while the duration of the fifth instar was 3.0 days on *Agaricus* and *Eupatorium* leaves, 3.1 days on yeast and 3.9 days on *Artocarpus* leaves. Total duration of embryonic and postembryonic development was 12.0 days on *Agaricus* and *Eupatorium* leaves, 12.6 days on yeast and 12.9 days on *Artocarpus* leaves. Differences noted in the total duration of embryonic and postembryonic life on different types of food were not significant at 5% level ($F = 2.35$). In the adult life of the female the reproductive showed period significant differences on different diets.

DISCUSSION

Collembola are known to lay eggs before they attained maximum adult size. Some species like *Lepidocyrtus lanuginosus* (HALE, 1965 b) started ovipositing in the fifth instar or even earlier as in *Tullbergia krausbaueri* in which the eggs were laid in the third instar (HALE, 1965 b). In *C. thermophilus* only the sixth instar started laying eggs as was found to be the case in *L. orientalis* (PRABHOO, 1967) and *Folsomia candida* (SNIDER & BUTCHER, 1973). The latter study indicated that although the mean juvenile period (pre-reproductive period) was 27.5 days, 17.7 days and 20.6 days at 15°C, 21°C and 26°C respectively, this variation had no influence on the instar starting to lay eggs. Present investigation revealed that apparently the food quality also had no influence on the instar starting oviposition and further there was only insignificant variation in the pre-reproductive period of the female under different diets.

Existence of a relationship between moulting and oviposition was reported in Collembola, which shared this feature with other arthropods in which moulting is

TABLE 1. Summary of observations on aspects of biology of *Cryptopygus thermophilus* reared at 30±1°C on four types of food. (Data pertains to the female only).

Type of food	No. of ovi-position	Clutch size (No. of eggs per ovi-position	Fecun-dity	Repro-ductive period in days	Post-repro-ductive period in days	Longe-vity in days	
	7	29.55	266	71	5	121	Min.
Yeast	23	43.9	921	143	40	161	Max.
	12.8	38.93	498.3	106.3	21	139.25	Mean
	10	30.64	327	81	15	115	Min.
Agaricus	13	33.09	430	96	22	116	Max.
	12.4	32.63	365.6	87.7	20.8	119.9	Mean
	7	13.4	164	71	3	110	Min.
Artocarpus	22	32.2	323	109	53	124	Max.
leaves	12.7	19.53	230.2	83.9	24.1	111.9	Mean
	4	13.6	68	23	3	65	Min.
Eupatorium	8	24.3	167	41	29	75	Max.
leaves	5.3	19.7	106	35.1	17.5	64.6	Mean
F value	10.53+	114.33++	50.12++	42.28++	0.48*	98.75++	

For each category n = 10; * not significant; + significant at 5% level; ++ significant at 1% level.

continued duriug adult life (PALEVODY, 1976). Possible lengthening of intermoult duration consequent to the interference by vitellogenesis was indicated by THIBAUD (1970). It appears from the previous studies that there are two distinct patterns of relationship between moulting and reproduction in these insects. In some species like *T. krausbaueri*, *Dicyrtoma fusca* and *D. minuta* (HALE, 1965 a), *L. orientalis* (PRABHOO, 1967) etc., the adult females laid eggs after each moult during the reproductive period. On the other hand egg laying occurred only in alternate instars as in *Isotoma viridis, Tomocerus minor* (JOSSEE & VELTKAMP, 1970), *Sinella curviseta* (WALDORF, 1971) and in *F. candida* (SNIDER & BUTCHER, 1973). This would mean that in these latter species there are alternate productive and non-productive instars. PALEVODY (1976) in a very interesting and detailed study clarified this relationship in *F. candida* and has shown that in this insect the first moult preceded vitellogenesis and the second moult occurred just before the oviposition. May be this is not a universal feature in Collembola. *C. thermophilus* falls in the first category as in this species oviposition was found to occur after every moult during the reproductive period. In *F. candida* oviposition takes place within 48 hours of the alternate moults (SNIDER, 1973). In *C. thermophilus* it may occur within 12 hours after every moult during the reproductive period. There is considerable variation in the number of ovipositions during the life time of female Collembola. HALE (1965 b) has summarised information on this aspect

from previous workers and the probable number of clutches were found to vary from 2-10. Mean number of ovipositions noted in *T. krausbaueri* and *Orchesella villosa* are reported to be 10. However, *F. candida* oviposited 13 times (mean) at 15°C and 21°C but only five times (mean) at 26°C thus indicating that temperature influenced the number of ovipositions (SNIDER & BUTCHER 1973). This latter is perhaps a general effect that temperatures near lethal point, increased instar duration and shortened life of Collembola (THIBAUD, 1970) thus leading to fewer oviposition. Present study showed that although the mean number of ovipositions was more or less the same (12.4—12.8) on yeast, *Agaricus* and *Artocarpus* diet, it was reduced to half (5.3) on *Eupatorium* diet and that this difference was significant statistically. Optimum temperature and optimum food quality thus appear to ensure high mean number of ovipositions. It is interesting to note that there was a steady decrease in the mean reproductive period under different diets from yeast to *Eupatorium* leaf in *C. thermophilus*.

A definite reproductive period noted in *C. thermophilus* was not observed in *F. candida* (SNIDER. 1973). Clutch size (number of eggs in one oviposition) in *F. candida* showed considerable individual variations and was found to be influenced by temperature, the relationship being inverse. Fecundity (total number of eggs laid by a female during its life time) was found to be on an avarage of 1344 eggs at 15°C, 1011 at 21°C and 130 at 26°C (SNIDER & BUTCHER, 1973). A high realized reproductive rate was suggested for Collembola on ideal food (BOOTH & ANDERSON, 1977; JOSSEE & TESTERINK, 1977). Present study showed that on favourable food both clutch size and fecundity were high and food quality was found to have very significant influence on both the charateristics. Longevity of Collembola was found to be very much affected by temperature (THIBAUD, 1970; SNIDER & BUTCHER, 1973), high temperatures shorteniug the life span. Present study revealed that longevity can also be affected by food quality and that a progressive shortening of life span was noted in females fed on yeast, *Agaricus, Artocarpus* leaf and *Eupatorium* leaf. It also emerges from the present study that food quality could play a decisive role in different aspects of the biology of Collembolan *C. thermophilus*. This has also possible ecological consequences. Thus one can logically predict a higher population density of *C. thermophilus* in a habitat dominated by *Artocarpus integrifolia* compared to a habitat where the prominent plant species is *Eupatorium*.

Acknowledgements: We are thankful to Prof. K. M. ALEXANDER for facilities in the Department. N C K is also thankful to the University of Kerala for the award of a Teacher Fellowship and for granting permission to publish this work.

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Entomon, 182, *Vol.* 7, *No.* 4, *pp.* 487 *to* 491

DESCRIPTION OF A NEW SPECIES AND RECORD OF TWO KNOWN SPECIES OF THE GENUS *LEUCOPHENGA* (DIPTERA : DROSOPHILIDAE) FROM INDIA

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Description of *Leucophenga pentapunctata*, a new species and two newly recorded species *L. regina* and *L. abbreviata* are given. Key to Indian species of *Leucophenga* is also provided.

(Key words: species, *Leucophenga)*

Leucophenga constitutes the third largest genus of the family Drosophilidae, with about 170 described species (Lin & Wheeler, 1972). Several more species have since been described from different parts of the world. Uufortunately our knowledge regarding *Leucophenga* species inhabiting the Oriental region is still very scanty and fragmentary. Altogether eight species have been recorded from India (Singh & Gupta, 1981). The present paper deals with the description of three species of *Leucophenga* from India one of which is new to science.

Genus Leucophenga Mik

Leucophenga Mik 1886; Wzener Ent. Zeitung 5:317. Type—Species: *Drosophila maculata* Dufour, Europe; Duda 1924, Arch. Naturgesh A, 90 (3) : 185.

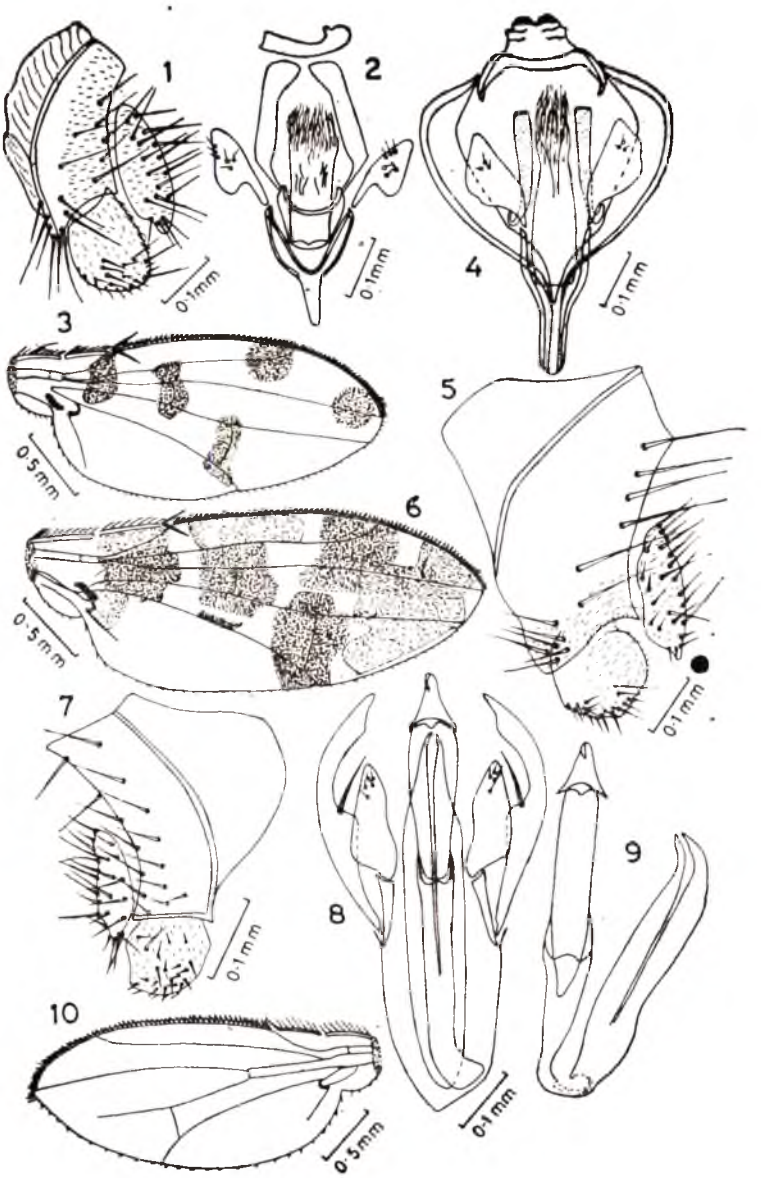
Leucophenga pentapunctata sp. nov.

Body length : 3.74 mm (♂)

Head, ♂: Arista with 7-8 branches above and 3 below in addition to small terminal fork. Antennae with second segment pale; third segment somewhat brownish. Frons including ocellar triangle pale brown. Orbitals in ratio 10:9:13; vibrissa long, second oral not differentiated. Palpi slender, brown distally, with several marginal setae. Carina absent. Face and cheek yellowish brown, greatest width of cheek 1/9 greatest diameter of eye. Post-vertical and ocellars moderate in size. Clypeus dark brown. Eyes dark red.

Thorax, ♂: Acrostichal hairs regular, in ten rows in front of dorsocentrals. Anterior scutellars, nearly parallel; posterior scutellars crossing each other. Anterior dorsocentral one third the length of posterior dorsocentral; distance between anterior and posterior dorsocentrals one-third the distance between anterior pairs. Pre-scutellars well developed. Mesonotum yellowish brown, with dark patch posteriorly, scutellum distally light. Thoracic pleura with two broad dark brown stripes. Sterno-index about 0.6.

Legs yellow, femora of all legs with a brown small dorsal patch basally; second and third tibiae with similar basal patch. Pre-apicals on all three tibiae; apicals on first and second tibiae.



Figs. 1—3 *Drosophila pentapuncta* sp. nov.: 1. Periphallic organs; 2. Phallic organs; 3. male wing. Figs. 4—6 *Drosophila regina*: 4. Phallic organs; 5. Periphallic organs; 6. male wing. Figs. 7—10 *Drosophila abbreviata:* 7. Periphallic organs; 8. Phallic organs; 9. Aedeagus with basal recurved process; 10. male wing.

CORRECTION

" Drosophila " above should be read as " Leucophenga "

Wings, ♂ (Fig. 3) With five conspicuous dark brown patches. One at first costal break; two elliptical patches, one on each cross vein, one each of the remaining patches on the tip of second and third longitudinal veins. Length about 3.12 mm. Approximate indices : C-index 1.55; 4V index 2.15; 4C-index 1.78; 5X-index 1.34; Two equal setae at the apex of first costal section; heavy setae near basal 1/11 of third costal section. Halteres entirely white.

Abdomen, ♂ : With IT-2T yellow, the remainder tergites with dark brown bands projected medially and laterally enclosing six-yellowish areas.

Periphallic organs (Fig. 1): Epandrium yellowish brown, pubescent, broadened below, with 7 setae on posterior margin and 8 similar setae on lower tip, basal fragma narrow. Surstylus large, pubescent, slightly longer than broad with 6 stout and 14-16 fine setae. Cerci yellow, pubescent, elongate with 18 setae.

Phallic organs (Fig 2): Aedeagus pale, straight and broad, apically hairy. Anterior gonopophyses narrow and apically triangular, each with 6 median sensilla. Posterior gonapophyses long, dagger shaped, slightly broadened distally. Ventral fragma narrow.

Holotype ♂, INDIA, ORISSA, Koraput district, Narayanpur, April 1981 (Panigrahy and Gupta). **Paratypes** : 4 ♂♂, same locality and collectors as holotype. Deposited in Museum of Department of Zoology, Banaras Hindu University, Varanasi, India and Department of Biology, Tokyo Metropolitan University, Tokyo, Japan.

Relationships: This species closely resembles *L. quinquemaculipennis* Okada (1966) in having wings with five dark patches; but distinctly differs from it in having narrow basal fragma (large in *quinquemaculipennis*), broad and apically hairy aedeagus (fusiform and pubescent on apical half in *quinquemaculipennis)*, anterior gonapophyses triangular with 6 sensilla (elongate with 4 sensilla in *quinquemaculipennis)*, posterior gonapophyses dagger shaped, slightly broadened distally (apically slender and medially thick in *quinquemaculipennis)*, and also in the abdominal pattern.

Distribution: INDIA

Leucophenga regina Malloch

L. regina Malloch, 1935, Aust. Zool. 8,90 (Mt. Molloy, north Queensland)

L. regina—Bock, 1979 Aust. J. Zool. Suppl. Ser., 71:34.

Head, ♂ : Palpi with 3-4 marginal setae. Vibrissa present second oral not differentiated. Greatest width of cheek 1/9 greatest diameter of eye. Clypeus dark brown.

Thorax, ♂ : Anterior scutellars divergent; posterior scutellars crossing each other. Humerals two, unequal. *wings*, ♂: (Fig. 6). As described by Bock (1979).

Legs and abdomen, ♂: As described by Bock (1979).

Periphallic organs (Fig. 5) : Epandrium brown, broadened dorsally with 6 long setae along posterior margin and 6 smaller setae at lower tip. Surstylus ovoid, pubescent, having 18 small setae. Cerci brown, pubescent, elongate with 23 setae

Phallic organs (Fig. 4): Aedeagus brown, straight broadened dorsally and hairy apically. Anterior gonapophyses brown, somewhat triangular, with 3 subapical sensilla. Posterior gonapophyses long narrowing basally. Ventral fragma narrow, hypandrium broad, narrowing basally.

Specimens examined: INDIA; Orissa, Koraput district, Narayanpur, 9 ♂♂, April 1981.

Distribution: Australia, India (New record).

Remarks: This species has so far been considered as very rare and confined to its type locality only (Queensland, Australia). But interestingly this beautiful and rare species has also been recorded from India.

Leucophenga abbreviata (de Meijera)

Drosophila abbreviata de Meijere, 1911: 400 (Java).

Drosomyiella abbreviata Hendel, 1914: 114 (Java, Taiwan).

Leucophenga abbreviata Duda, 1924 a: 185 (Java), Okada, 1966, Bull. Brit. Mus. (Nat. Hist) Ent. Suppl. 6:18 (Nepal).

Head and Thorax, ♂: Orbitals in the ratio of 10:9:15. Other details as described by Okada (1966).

Wings, ♂ (Fig. 10): As described by Okada (1966).

Legs and abdomen, ♂: As described by Okada (1966),

Periphallic organs (Fig. 7): Epandrium uniformly broad, truncate below, with 15 setae along posterior margin, basal fragma large. Surstylus somewhat quadrate, pubescent, with 20 small setae and a few fine setae. Cerci elongate, with 24 setae.

Phallic organs (Figs. 8 and 9); Aedeagus brown, elongate, bifurcatated at upper half, basally with a long recurved process, hooked apically. Anterior gonapophyses large having narrow stalk and with 5 sensilla subapically. Ventral fragma slender, lateromedially somewhat swollen. Hypandrium narrow, apically pointed, with a pair of submedian spines.

Specimens examined: INDIA, Orissa, Koraput, district Narayanpur, 10 ♂♂, April 1981.

Distribution: Java, Taiwan, Nepal, India (New record).

KEY TO INDIAN SPECIES OF THE GENUS *LEUCOPHENGA*

The authors have included all the species recorded so far from India, although not all of them were examined by the authors.

1 Media distally abbreviated, not reaching wing margin ..... *abbreviata* (de Meijere)

— Media distally not abbreviated and reaching wing margin 2

2 Third abdominal tergite in male bare and milky-white ..... *albofasciata* (Macquart)

— Third abdominal tergite in male not bare and milky-white 3

3 Wings with darkened areas 4

— Wings without darkened areas 5

4 Wings largely fuscous apically ..... *neoangusta* Godbole & Vaidya

— Wings with definite patches of different shapes and sizes 6

5 Basal three abdominal tergites with silvery effect and the remainder shiny black ..... *flavicosta* Duda

— Basal three abdominal tergites without silvery effect and the remainder not shiny back 7

6 Mesonotum and basal tergites in the male covered with dense silvery pollinosity. Wing with a basal diagonal stripe ..... *subpollinosa* (de Meijere)

— Mesonotum and basal tergites in male not covered with dense silvery pollinosity. Wing without a basal diagonal stripe 8

7 Abdominal tergites with broad black bands, projecting medially and laterally ..... *shillongensis* Dwivedi & Gupt

— Abdominal tergites with black spots 9

8 Wings with a dark area extending across costal margin, clearls interrupted just beyond seccond costal break ..... *interrupta* Duda

— Wings not with a dark area extending across costal margin but with defined patches 10

9 Thoracic pleura yellow with scattered black patches ..... *rimbickana* Singh & Gupta

— Thoracic pleura yellowish orange, slightly clouded in male ..... *bellula* (Bergroth)

10 Wings with extensive brown markings of irregular outline. Abdominal tergites with bristles arising from distinct black spots ..... *regina* Malloch

— Wings with five conspicuous dark brown areas. Abdominal tergites with bristles not arising from distinct black spots ..... *pentapunctata* sp. n.

Acknowledgements: The authors wish to express their gratitude to Dr. T. Okada, Emeritus Professor, Department of Biology, Tokyo Metropolitan University, Tokyo, Japan for confirming the identifications. Thanks are also due to Prof. M. S. Kanungo, Head of the Zoology, Department for facilities. The senior author (KKP) is thankful to U G C for awarding teacher-fellowship under the Faculty Improvement Programme.

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Entomon, 1982, *Vol.* 7, *No.* 4, *pp.* 493 *to* 497

DROSOPHILA NEOIMMIGRANS, A NEW SPECIES FROM SOUTH KANARA, INDIA (DIPTEA : DROSOPHILIDAE)

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(Received 10 April 1982)

Drosophila neoimmigrans, sp. nov,, a member of the "typical" *immigrans* subgroup of the *immigrans* species group collected from South Kanara District is described. The systematic position and relationships are discussed.

(Key words: Drosophila neoimmigrans, new species, *immigrans* subgroup*)*

The Western ghats is known to harbour a number of *Drosophila* species because of its excellent ecogeographic conditions. The collection reports of Prakash and Reddy (1977, 1978, 1979 and 1980), Muniyappa and Reddy (1980) have revealed some new species. In view of the rich abode offered by the Western ghats for a variety of rich insect fauna, it is possible that several *Drosophila* species, which are unknown to science may also be available in these localities. Hence a collection trip was undertaken to investigate the *Drosophila* fauna of the Western ghats. A new species was collected at Puttur and surrounding areas (12° 21′ N and 13• 58′ N latitude and 74° 35′ and 74° 40′ E longitude) which is herein reported.

Drosophila neoimmigrans, sp. nov. (Figs. 1—7)

Male and *female:* Large dark brown flies, pigmentation in males darkens with age.

Body length: Male 3.06 mm, Female 3.18 mm.

Head, ♂ and ♀: Arista with 10 branches (6-4) including terminal fork. Front dark brown. Antenna brownish black. Cheek with 2 vibrissae, both of which are curved. Palpi light brown with 3 large straight bristles and few smaller ones. Carina broad with a few small bristles. Orbital bristles in the ratio of 2:1:2. Eyes deep red. Inner and outer verticals of same size and reclinate. Postverticals crossed and convergent. Ocellar triangle broad with 2 long bristles.

Thorax, ♂ and ♀: Dark brown. Acrostichal hairs in 8 rows, regularly placed. Anterior dorsocentrals reclinate. Ratio; anterior : posterior dorsocentrals 0.5. Scutellum dark brown. Anterior scutellars convergent, posterior scutellars convergent and crossed. Anterior and posterior sternopleurals of equal size. Middle sternopleural shorter than anterior and posterior. Prescutellars absent.

Wings, ♂ and ♀: Smoky. Wing length 2.67 mm (male). 2.81 mm (female).

	C-index	4V-index	4C-index	5X-index	M-index
♂	3.95	1.22	0.47	0.81	0.29
♀	3.86	1.29	0.44	0.85	0.30

Third costal section with heavy setation on basal ♂ and ♀ 0.6. (Wing indices

Figs. 1—17. *Drosophila neoimmigrans* sp.:
1. Fore leg of male.

calculated after Okada, 1956 and Bock, 1976). Halteres small, brownish.

Legs: Pre-apicals on all tibiae, apicals only on first tibia. A row of 7 to 9 short thick peg like bristles (cuneiform) on the inner side of first femur. Sex comb absent (Fig. 1).

Abdomen, ♂ and ♀: The tergites of males and females are dark brown. Abdominal tergites and sternites of males darken with age.

Periphallic organs (Fig. 2): Epandrium (Genital arch) narrow, with broad anterior end. Toe with 2-3 long bristles. Heel narrow with 3-4 bristles. Primary surstylus (primary clasper) present with 7-9 stout blunt teeth arranged in a concave row and with 2-3 stout short inwardly curved bristles. Secondary surstylus (secondary clasper) absent. Cerci (anal plate) more or less kidney shaped bearing 20-25 long bristles uniformly distributed except at posterior end which carries 2 short bristles. Cerci independent of epandrium.

Phallic organs (Fig. 3): Aedeagus yellow, cylindrical, small apically pointed with petal like arrangement. Anterior gonpophyses (anterior parameres) club shaped articulating with aedeagus and without hairs. Posterior gonapophyses (posterior parameres) long, reaching tip of aedeagus. Caudal margin of nova-sternum truncate, bearing 4 spines. Basal apodeme projecting beyond ventral fragma.

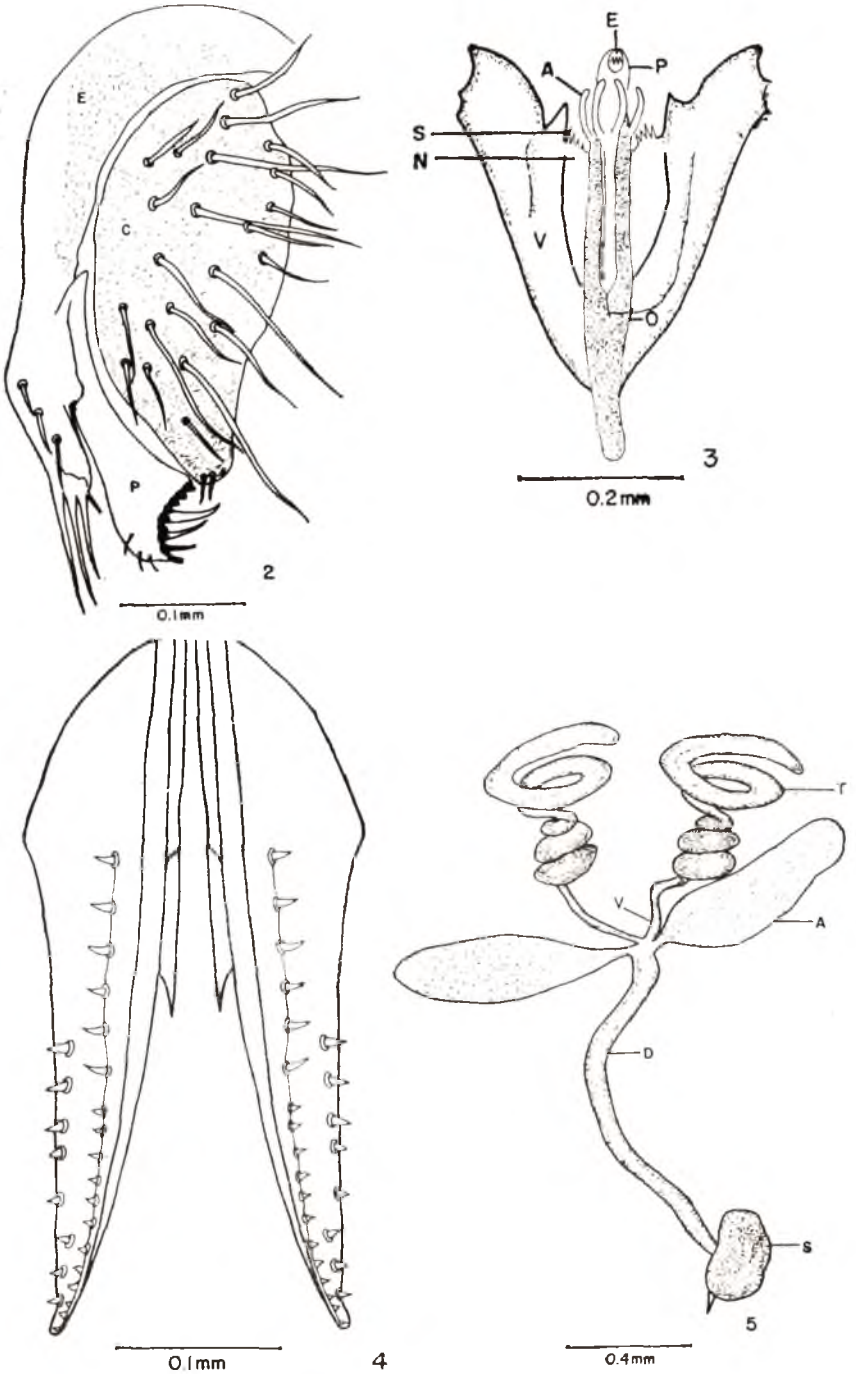

Fig. 2. Periphallic organs, C—Cerci, E—Epandrium, P—primary Surstylus, 3. Phallic organs, A—Anterior gonopophyses, E—Aedeagus, O—Ejaculatory Apodeme, P—Posterior gonopophyses, S—Spine of Novasternum. 4. Egg guide. 5. Male reproductive organs, T—Testes, V—Vas deferens, A—Accessory gland, D—Anterior ejaculatory duct, S—Ejaculatory bulb.

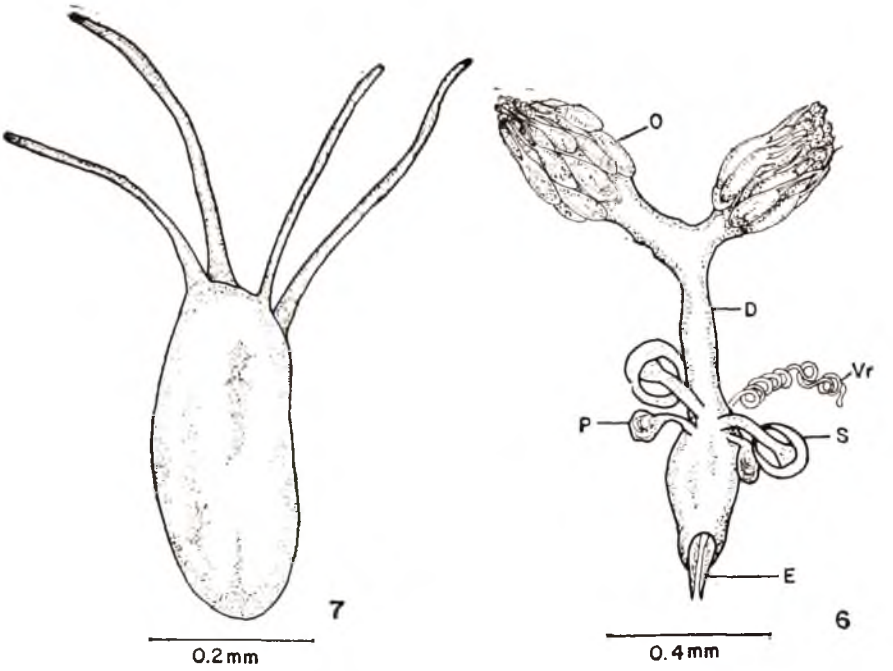

Fig. 6. Female reproductive organs, O—Ovary, D—Oviduct, P—Paraovaria, S—Spermatheca, V—Ventral receptacle, E—Egg guide. 7. Egg.

Egg guide (Fig. 4) Pale yellow with about 18 median teeth and 7 marginal teeth.

Internal structures: Testes (Fig. 5) deep orange with 5 coils. Accessory glands large and transparent. Ejaculatory bulb globular. Spermathecae (Fig. 6) yellowish and round. Paraovaria ovoid, ventral receptacle with several coils. Malpighian tubules two and fused.

Egg filaments (Fig. 7): Four long slender filaments with tapering ends.

Pupae: Anterior spiracle with 16 branches arranged in a rosette like manner.

Distribution: INDIA, Karnataka, South Kanara District Western Ghats.

Holotype ♂, INDIA, KARNATAKA: Sampaje Ghats and Puttur, South Kanara District, 16. viii. 1981. Coll. P. G. Gai, N. B. Krishnamurthy and S. N. Hegde. Deposited in the Museum of Department of Zoology, University of Mysore, Manasa Gangotri, Mysore. **Allotype** ♀ (data same as above). **Paratypes:** 25♂♂, 22 ♀♀ (data same as above) 5 ♂♂ and 5♀♀ deposited in the Department of Biology, Tokyo Metropolitan University, Setagaya-ku, Tokyo, Japan and some will be deposited in the Zoological Society of India, Calcutta.

Relationship and **Remarks:** The presence of 4 egg filaments with tapering ends and spiral tests justifies its inclusion in the subgenus *Drosophila* (Patterson and Stone, 1952). A row of 7-9 short thick peg like bristles (cuneiform) on the inner side of the front femur; presence of non-prominent heel; toe that does not cover primary surstylus; a concave row

of chitinized teeth on primary surstylus and absence of secondary surstylus warrants the inclusion of this species in the *immigrans* species group (Hsu, 1949; Okada, 1956 and Wilson *et al.*, 1969).

Okada (personal communication, October, 1981) has pointed out that the new species belongs to the *immigrans* group. On comparison with the other members of the *immigrans* group, the species under study shows close resemblance to that of *D. immigrans*, Sturtevant, 1981, in having a narrow epandrium; nonprominent heel; protruding primary surstylus (Hsu, 1949) similar spermathecae, ventral receptacle and paragonia (Throckmorton, 1962). But it distinctly differs from *D. immigrans* in the presence of 8 chitinized teeth of uniform size on the primary surstylus; blunt toe and also in regard to pigmentation in male which darkens with age. It is interesting to note that the testes in the present species is made up of 5 coils, which is an uinque feature. This and other charactors such as presence of 8 chitinized teeth of uniform size on the primary surstylus, blunt toe, pigmentation in males which darkness intensely with age demand an independent status for this new species. The new species is named *Drosophila neoimmigrans*, as it closely resembles *D. immigrans*.

Acknowledgements: The authors are highly thankful to Professor T. Okada, Gotokuji 2-3-18, Setagaya-ku, Tokyo, Japan for his help in identifying the species. One of us (P G G) is thankful to the University of Mysore and U G C for the award of Teacher Fellowship under Faculty Improvement Programme. We also thank Dr. S. N. Hegde and Dr. V. Vasudev for their helpful discussions and Dr. S. R. Ramesh for the preparation of the drawings. We thank Sri M. G. Vasudev Rao for his help in taking photographs.

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Entomon, 1982, *Vol.* 7, *No.* 4, *pp.* 499

REPORTS AND NEW RECORDS

NEW RECORD OF A CHALCID PUPAL PARASITE *BRACHYMERIA (MATSUMURAMERIA) CRICULAE* (KOHL) ON *METANASTRIA HYRTACA* CR (LASIOCAMPIDAE : LEPIDOPTERA)

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(Received 12 June 1982)

Brachymeria (Matsumurameria) criculae (Kohl) (Chalcidae : Hymenoptera) is recorded as pupal parasite on *Metanastria hyrtaca* Cr. feeding on Jamun.

The genus *Brachymeria* Westwood of the family chalcidae is widely distributed and acts as parasites of many pests of agricultural importance and the information about the hosts and distribution of many species of this genus is lacking and incomplete (Narendran and Joseph, 1975). Joseph *et al.* (1973) recorded several hosts of *Brachymeria* from other countries and India. *Brachymeria lasus* (Walker) which is an important entomophagous pupal parasite on the pests of crops and vegetables was recorded on several lepidopterous pests during 1976 by Narendran and Joseph. The host of another new species *B. bouceki* was published by Narendran in 1978.

In the present studies *Brachymeria (Matsumurameria) criculae* (Kohl) (Chalcidae : Hymenoptera) has been recorded as pupal parasite on *Metanastria hyrtaca* Cr. feeding on Jamun at Hyderabad during March-April, 1981. The host caterpillar occurs on a variety of trees like, *Terminalia catappa* L , *Mimusops elengi* L. *Achras sapota* L., *Guazuma tomentosa* Kunth., *Nyctanthes arbortristis* L., *Bassia longifolia*, *Sohima wallichii* Choisy, *Syzygium jambolana* Lamk., *Acacia arabica* Willd., *Albizia stipulata* Boir, *Anthocephalus cadamba* Miq and *Moringa oleifera* Lamk. (Nair, *et at.*, 1976) and it has been reported as a sporadic pest on Jamun (Ayyar, 1963). The parasites took 12-15 days to emerge from the host pupa. The number of emerging parasites ranged from 40-65 with an average of 52 from each pupa.

Acknowledgements: The parasites were identified by Dr. T. C. Narendran and Professor K. J. Joseph, Department of Zoology, University of Calicut, Kerala, India, to whom the authors express their thanks.

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Entomon, 1982, *Vol.* 7, *No.* 4, *pp.* 500

LEPIDOSAPHES MCGREGORI BANKS, A NEW HARD SCALE INFESTING COCONUT

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(Received 20 June 1982)

A new species of hard scale *Lepidosaphes mcgregori* Banks (Diaspididae) was found infesting the leaves and fruits of coconut in certain areas of Trivandrum District in 1981.

Many species of *Lepidosaphes* are known to infest different crops like apple, citrus, pepper, mango, pomegranate, etc. (Nair, 1975). *Insulaspis vermicula* (Mamet) *(Lepidosaphes vermiculus)* is reported from Puerto Rico on coconut and *Yucca* sp. (Anon, 1978). This is the first report of *L. mcgregori* infesting coconut.

Clusters of these clongated scales were seen on the upper surface of coconut leaflets (Fig. 1) and on the surface of tender coconuts in thousands. The leaves of the outer whorls infested by the scales resulted in complete drying up of the whole fronds and the trees presented a completely burnt-up appearance. The tender inner leaves were not seen infested by the scales. The scales were found on the inner surface of the leaflets as well, but the population was comparatively less. When the infestations begin typical yellowing in patches were seen on the leaves which later on resulted in complete drying up. Occurrence of the scale on the nut surface did not cause any damage.

The adults are pinkish in colour and elongated. The mature scales showed about 8-10 eggs per scale at the anal end. The crawlers which come out through the lifted margin of the scale after hatching, move about and cover themselves with a greyish circular band after settling on the leaf surface. The moulted skin is seen on these bands and the scale construction continues till the beginning of oviposition by the adult females.

These scales are controlled by spraying dimethoate 0.05 per cent or carbaryl 0.2 per cent.

D. J. Williams of Commonwealth Institute of Entomology, London, identified the species and our thanks are expressed to him for it.

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BOOK REVIEW

COCONUT CATERPILLAR AND ITS NATURAL ENEMIES

By U. V. K. MOHAMED, U. C. ABDURAHIMAN & O. K. REMADEVI, 1982, Zoological Monograph No. 2 Division of Entomology, Department of Zoology, Calicut University, India 673 635. 162 pp.

This monograph attempts to provide rather detailed accounts of the entomophagous insects associated with *Nephantis serinopa* Meyrick, an injurious pest of the coconut palm. In view of the vital role that coconut palm plays in the economy of the West coast of South India and some neighbouring countries like Sri. Lanka, this work can be of considerable interest to scientists as well as cultivators.

First part of this work gives a broad outline of the importance of the coconut palm, history of *Nephantis serinopa*. (The authors inform that the current name of *N. serinopa* Meyick is *Opisina arenosella* Walker.) Infestation in Kerala, the life-history of this pest and some information on the damage done to the coconut palm by this pest. Part II gives information on the biology of the predators and parasites. Previous work on this aspect is briefly reviewed and a list of predators and parasites reported earlier together with newly discovered ones is given. Adult morphology, life history, reproductioon and mating behaviour and other relevant details are given of three larval, one prepupal and five pupal parasites as well as three predators together with techniques of mass rearing of the parasites.

Based on a collection of 11,724 host stages from southern and Northern districts of Kerala the authors have attempted an evaluation of the efficacy of the parasites and predators. Control effeciency of the parasites has been judged based on percentage infestation of the host stages and accordingly suitability of the parasites hasbeen found to be in the order *Apanteles taragamae*, *Parasierola nephantidis*, and *Meteoridea hutchinsoni*, a newly recorded larval parasite, while suitability of pupal parasites was in the order *Brachymeria nephantidis*, *Trichospilus pupivora* and *Brachymeria nasatoi*. The authors suggest simultaneous use of a complex of effecient parasites and predators to achieve better control of the pest and use of several species of *Brachymeria* and also the newly recorded parasite *M. hutchinsoni* is advocated.

Researchers interested in biological control and students of entomology in general would find this monograph informative and interesting.

N. R. PRABHOO

BIORESOURCES ECOLOGY

BY T. N. ANANTHAKRISHNAN, 1982, Oxford & IBH Publishing Co., New Delhi Bombay, Calcutta. 159 pp. Rs. 60/-

This book is written with a view to giving an idea of the major renewable resources of India for their scientific utilisation by the fast growing population of this country.

There are eight chapters in this book of which the first three deal with general ecological principles and the remaining ones with terrestrial, marine and fresh water resources and bioenergy. Entomologists would find chapter 4 interesting as major part of this section is devoted to insect resources. Lac insects and lac cultivation, silk moths, honey bees and other insects are dealt with in this chapter. Many interesting details are given concerning the biology of lac insects including

information on the two strains producing *rangeeni* and *kusumi* varieties of lac, various host plants of the lac insect, basic ecological conditions that influence lac production and the new host plants that are being tried for increasing lac production in this country. A crop calender provides information on the crop seasons of the two strains and a map gives information on major and minor lac growing areas in India. Brief but precise accounts of the biology of different species of silk moths producing the four major varieties of silk are given with their distribution in this country. Supplemented with information on silk production. This is followed by an account of bees and bee-keeping and brief accounts on other kinds of insects yielding oil, dyes etc.

This book is a handy source of information of general ecological interest and all teachers of biology and entomology would find it very useful as a teaching aid. It is also a unique attempt in ecological literature in the sense that it lays major emphasis on ecological function touching the structure only in most general terms. Being profusely illustrated with diagrams and graphs and with tabular data, people with little background of biology like economists, engineers, environmentalists and planners would also find it readable.

N. R. PRABHOO

OBITUARIES

Dr. G. A. GANGRADE

Dr. Govind Amarchand Gangrade was born on All Fools' day of 1922 in the village Borgaon Buzurg (Kandwa, M. P.). He had his early education at Nagpur and got B. Sc. (Agri.) degree of Nagpur University in 1946. He joined Indian Agricultural Research Institute, New Delhi and got his Associateship in Entomology in 1954. For Ph. D. degree, he did the course work at University of Illinois (USA) followed by Research at IARI New Delhi with specialisation in chemosterilants for insect pest management.

He joined Agricultural Service of old Madhya Pradesh on 8-6-1946 as Research Assistant in Entomology at Nagpur. After the reorganisation of the States, he joined the College of Agriculture, Jabalpur in 1956. He served J. N. Krishi Vishwa Vidyalaya, Jabalpur as Senior Lecturer, Associate Professor and later as Associate Director Research, training a good number of M. Sc. and Ph. D. students. He also worked as Principal Investigator in PL-480 Scheme on "Assessment of effects on yield and quality of soybean by major arthropod pests" and in "Operational Research Project on Insect Pests of Paddy". He was deputed for higher training in Entomology to England and USA and was also invited as Guest Speaker at Regional Soybean Conference for the Middle East, Africa and South Asia held at Addis Ababa. Dr. Gangrade has over sixty scientific papers to his credit including a Technical Bulletin on 'Insects of Soybean'. He was very popular as a teacher among the students and was always regarded as a good research worker by his superiors.

He left for heavenly abode on May 8th 1981.

DHAMO K. BUTANI

K. K. NIRULA

Dr. Kamal Krishan Nirula was born on 5th May 1917 at Jung (Punjab, Pakistan). He had his early education at Lahore and got B. Sc. (Hons.) and M. Sc. (Hons.) degrees from University of Punjab (Pakistan) in 1938 and 1939 respectively. He got his Associateship IARI in Entomology in 1942.

After the partition of the country, he migrated to India and joined Central Crop Research Institute. He worked on insect pests of coconut at the Coconut Research Station, Kayangulam (Kerala). The results of his research findings were submitted in the form of thesis for which he was awarded Ph. D. degree by University of Punjab (India).

Dr. Nirula joined Central Potato Research Institute and worked as Entomologist at Simla and Patna. He joined Directorate of Plant Protection, Quarantine and Storage, Government of India and worked as Deputy Director (Training) at the Plant Protection Training Institute, Hyderabad in 1969 and was later promoted as Project Director. After his retirement from government services in 1975 he joined ICRISAT at Hyderabad as Plant Quarantine Officer. In 1980 he was appointed as Plant Quarantine Consultant to FAO and it was in Rome (Italy) on 30th August 1981 where he died with his boots on.

DHAMO K. BUTANI

ANNOUNCEMENTS

REVISION OF SUBSCRIPTION RATES

Entomon was started as half-yearly journal in 1976, when the present tariff was fixed. With the current issue, vol. 7 is complete and the journal is entering 8th year of its publication. Meanwhile, the journal has become a quarterly; it has been able to accommodate more articles and has under-gone qualitative and quantitative growth. Cost of production has been tremendously increasing all this time. Thus after 7 years of its existence, we are compelled to increase our subscription rates much against our wish. The new rates will be: Rs. 150/- in India and $50/- abroad. However, we are pleased to keep individual subscription rates unaltered in the interest of maximum dissemination of knowledge to enable individuals to subscribe to the journal at much reduced rates. Individual subscription rates will continue to be: Rs. 50/- in India and $20/- abroad. All the rates are inclusive of usual postage (by sea mail abroad). Air surcharge will be $20/- to all countries—Secretary-Treasurer, A. A. E.

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Printed by V. K. K. Prabhu at GEO Printers, Plamood, Trivandrum 695 004
for the Association for Advancement of Entomology.